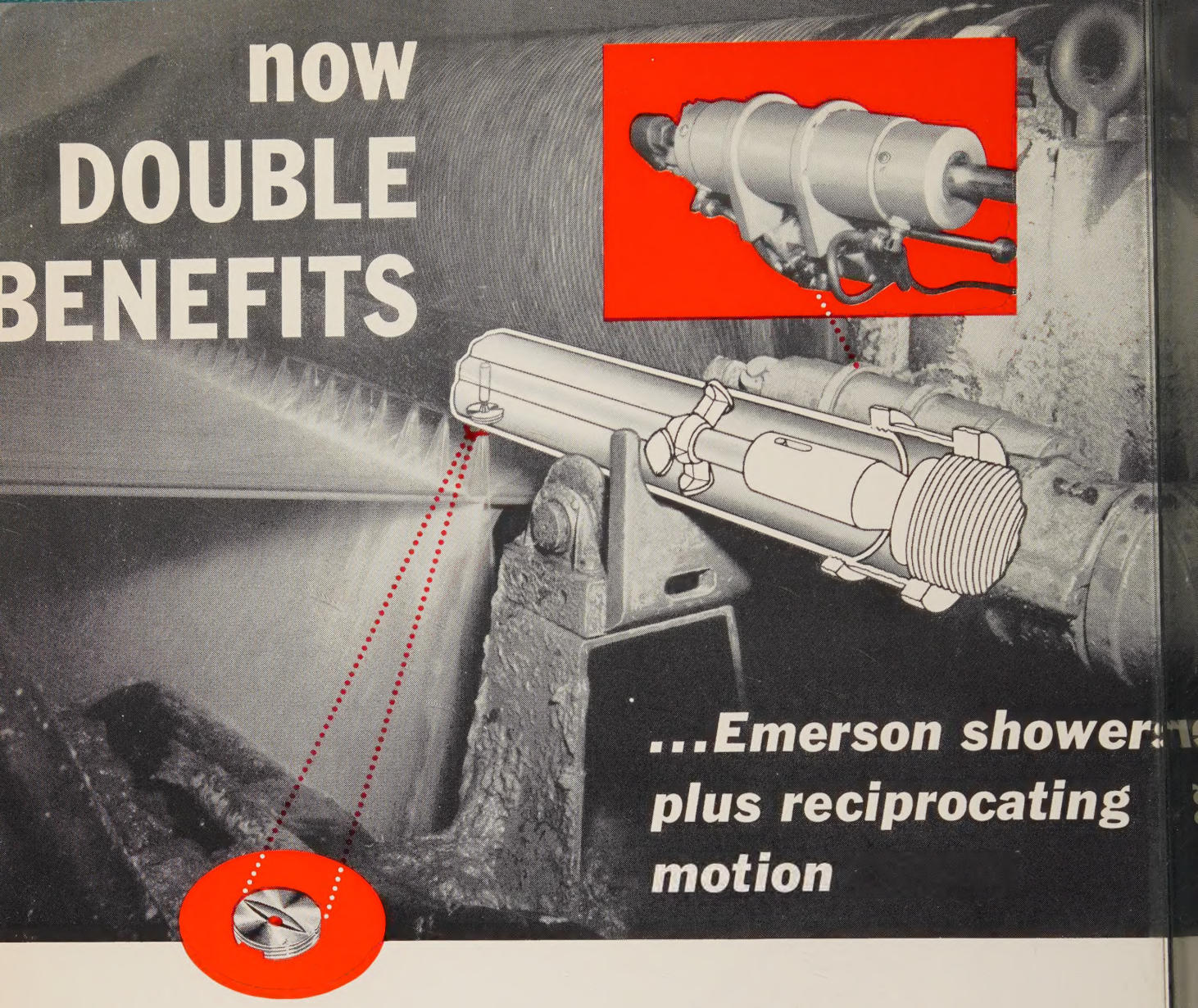
Tappi

THE JOURNAL OF THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

SEPTEMBER 1960

VOLUME 43 • NUMBER 9

now DOUBLE BENEFITS



...Emerson showers plus reciprocating motion

"With Emerson Reciprocating Showers on the job the downtime saved from having to clean wires frequently has helped increase production nearly 5% on our wide variety of basis weights," says RUSSELL W. HAMILTON, Resident Manager, St. Regis Paper Company, Nashua River Division. *"Wire life has been lengthened too, in spite of increasing the machine speed more than 14% on the light basis weights.*

"Ridging and spots are eliminated because water pressure is equally distributed across the wire. Even if a nozzle becomes temporarily clogged the horizontal back-and-forth spray coverage makes up for it. Foreign materials have little chance of forming on the wire, which improves sheet formation."

Designed for white water systems, as well as fresh, Emerson Reciprocating Showers hold water costs to a minimum and check the loss of solids. This is due to Emerson's internal clean-out mechanism. Stainless steel brushes, positioned opposite each nozzle, clear the openings of lumps by a simple twist of the handle. As brushes momentarily cover the nozzle openings, a valve opens to permit complete end-to-end flushing of the pipe.

Emerson Reciprocating Showers come in pipe diameters of from 1½ to 6 inches, in lengths to 376 inches. Each is engineered for its particular application with the proper nozzle size and spray pattern specified.

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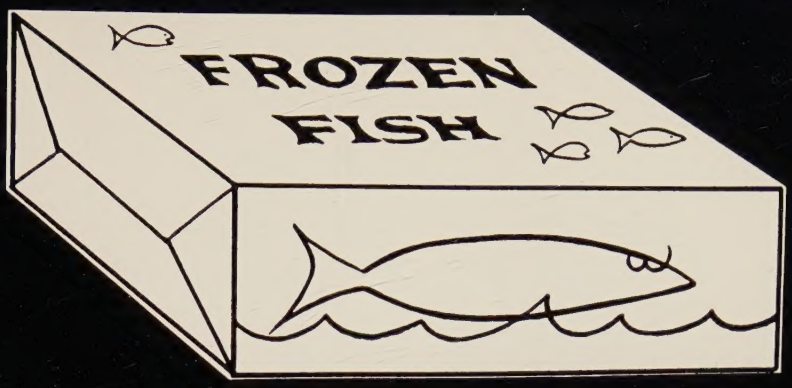

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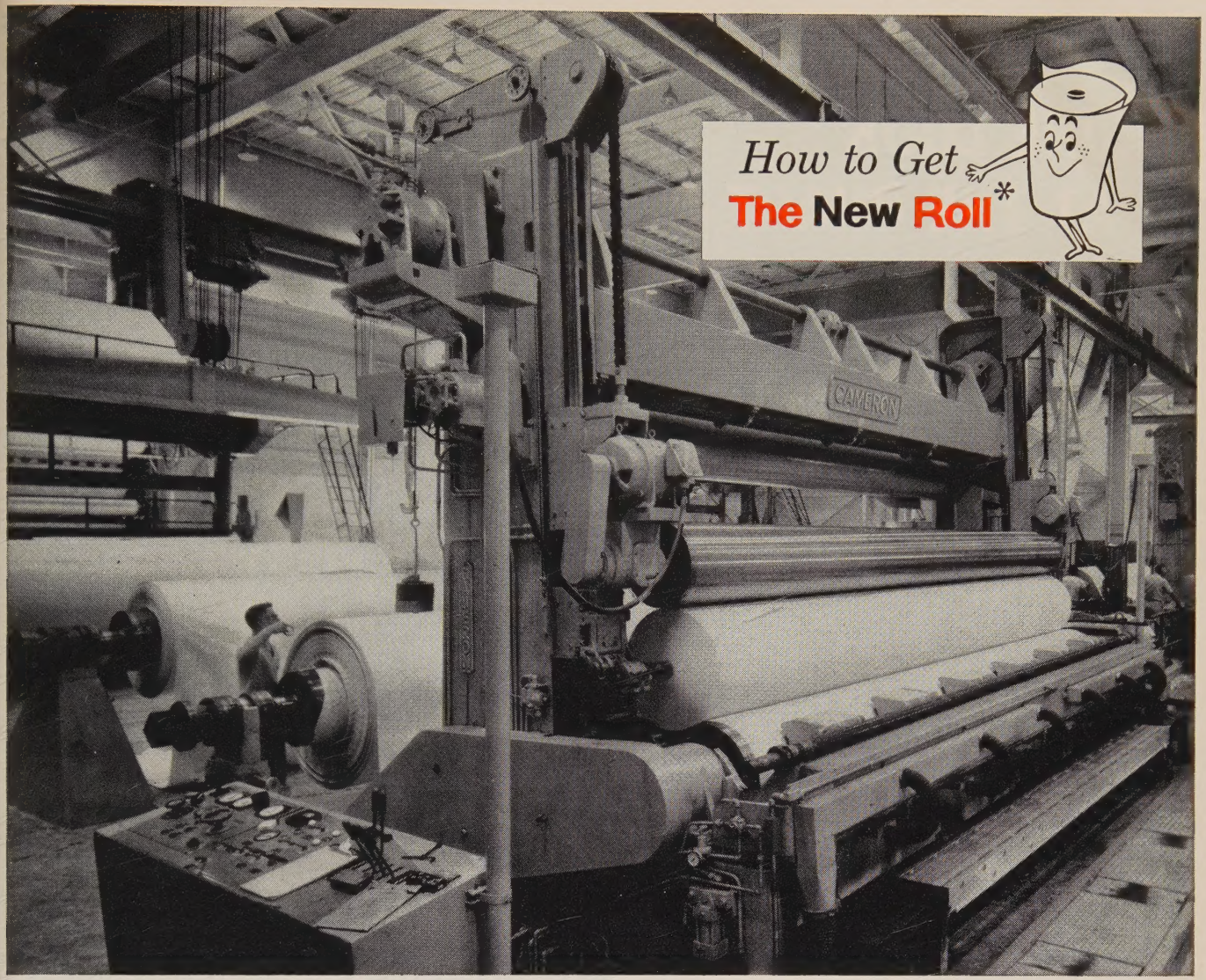

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In the action photograph above a new Cameron Imperial winding system, integrated from unwind to rewind, (246″ trim width, 72″ rewind capacity) is running at speeds up to 5000 fpm* on 28 to 85 lb. coated book papers. Here are some of the features of this job-fitted Cameron system:

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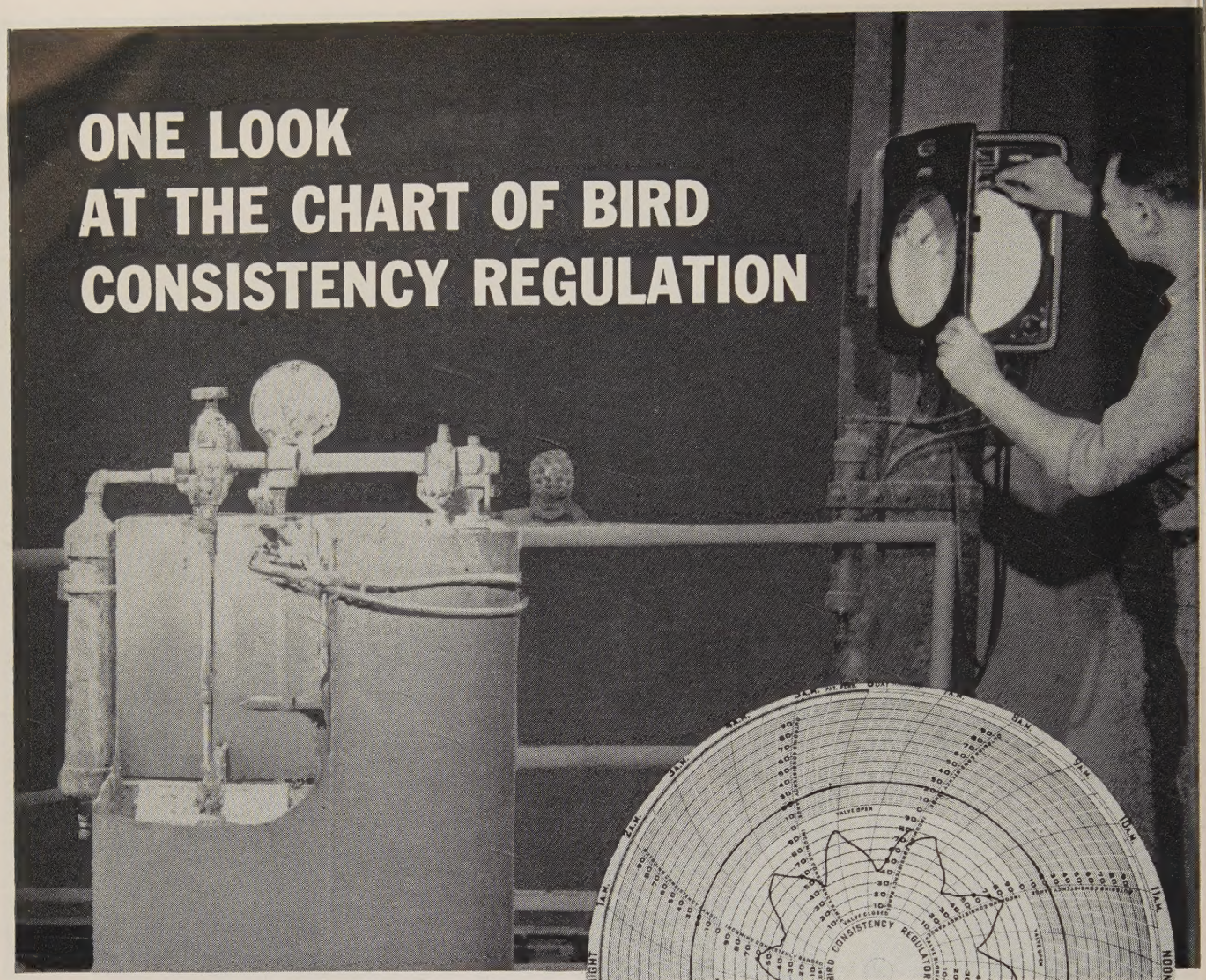

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published monthly by the

Technical Association of the Pulp and Paper Industry

at 20th and Northampton Streets
Easton, Pennsylvania

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New York 17, New York

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Tappi is published monthly by the Technical Association of the Pulp and Paper Industry at 20th and Northampton Streets, Easton, Pa. Editorial and advertising offices, 360 Lexington Avenue, New York 17, N. Y. Articles for publication and communications regarding the editorial content of **Tappi** should be addressed to the Editor at the editorial office. Statements and opinions expressed in articles and editorials appearing in **Tappi** are those of the contributors, and the Technical Association of the Pulp and Paper Industry assumes no responsibility for them.

Subscription: U. S. and possessions $10.00; Canadian $11.00; Pan American Union $12.00; Other Foreign $13.00. Single copies to members of TAPPI $1.00; Non members $1.50.

Second-class mail privileges authorized at Easton, Pa. Acceptance for mailing at a special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized January 27, 1949.

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The Technical Articles are in accord with the recommendations of the Division of Pulp, Paper, and Board of the International Union of Pure and Applied Chemistry.

All the publications of the Technical Association of the Pulp and Paper Industry may be obtained from the offices at 360 Lexington Avenue, New York 17, N. Y.

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Pantlind Hotel, Grand Rapids, Mich.
Sept. 27–29, 1960.

Fifth Deinking Conference
Conway Hotel, Appleton, Wis.
Oct. 5–7, 1960

Tenth Corrugated Containers Conference
Royal York Hotel, Toronto, Ont.
Oct. 10–13, 1960.

Fifteenth Plastics-Paper Conference
Hotel Syracuse, Syracuse, N. Y.
Oct. 17–19, 1960.

Fifteenth Engineering Conference
Robert Meyer Hotel, Jacksonville, Fla.
Oct. 24–28, 1960.

Fundamental Research Conference
Northampton Hotel
Northampton, Mass.
Nov. 3–5, 1960

Please refer to Local Section Activities for the locations and dates of Section meetings

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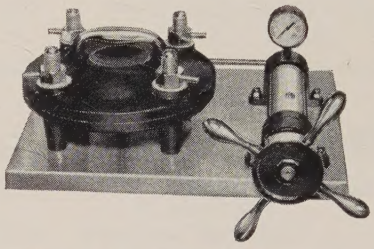

Mounted on 18-8 Stainless steel base. Press on base, or pump only may be purchased separately. (T-205 m)

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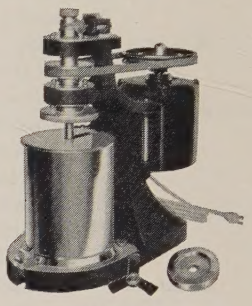

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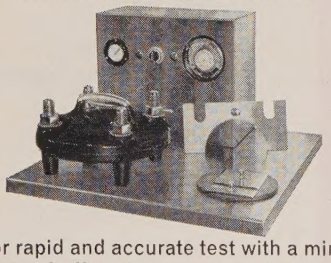

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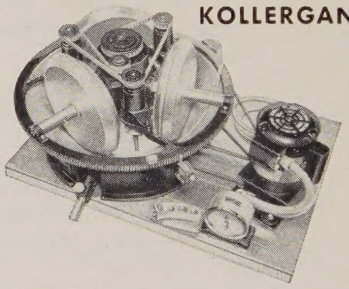

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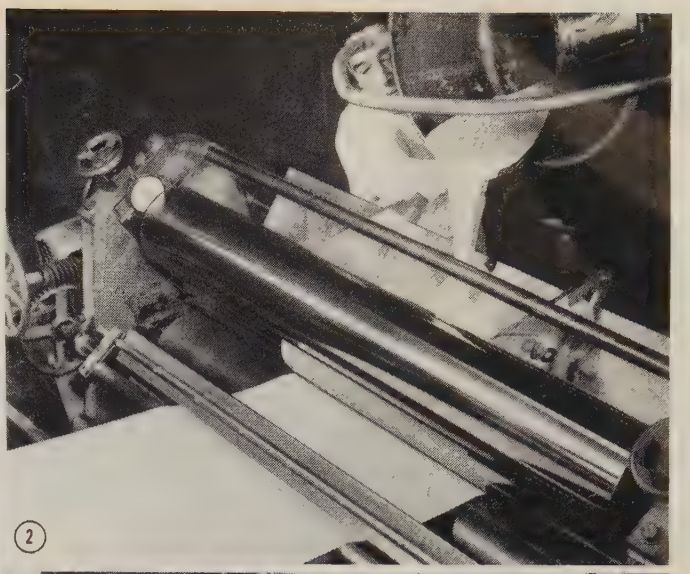

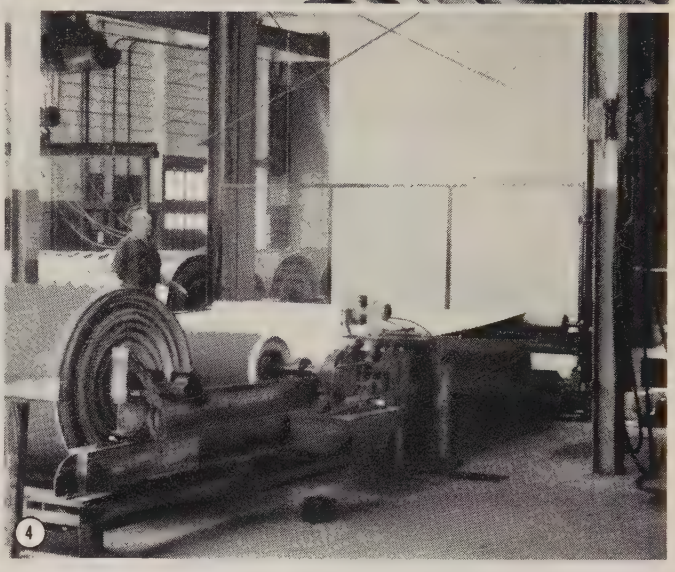

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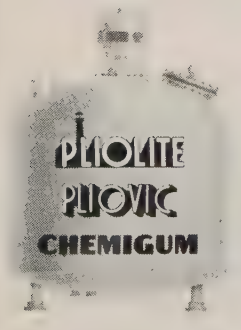

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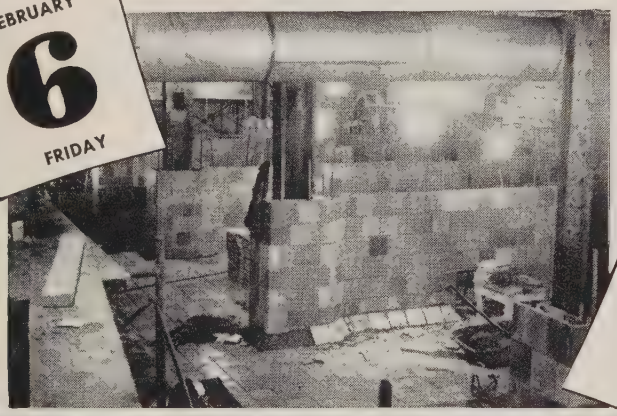
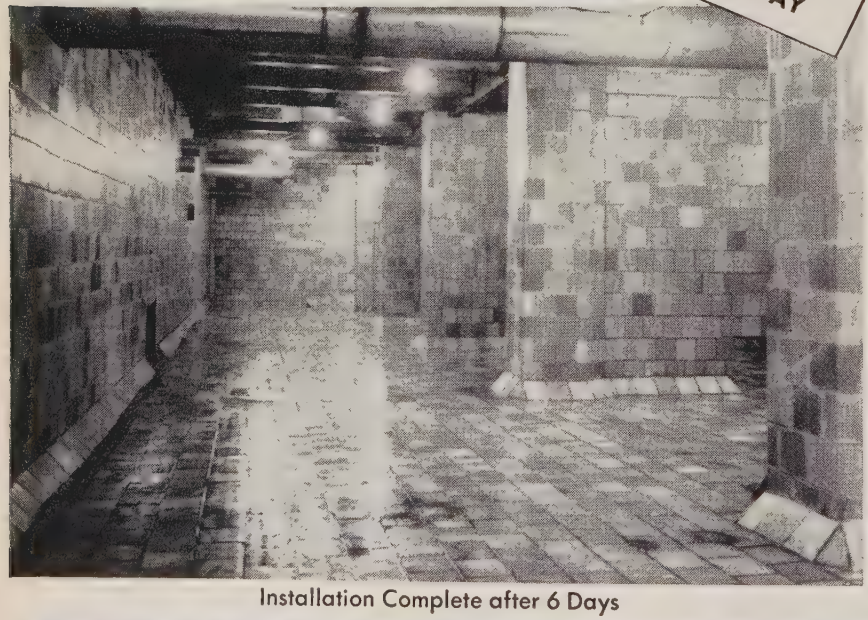


FEBRUARY 8 MONDAY



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20,000 common brick
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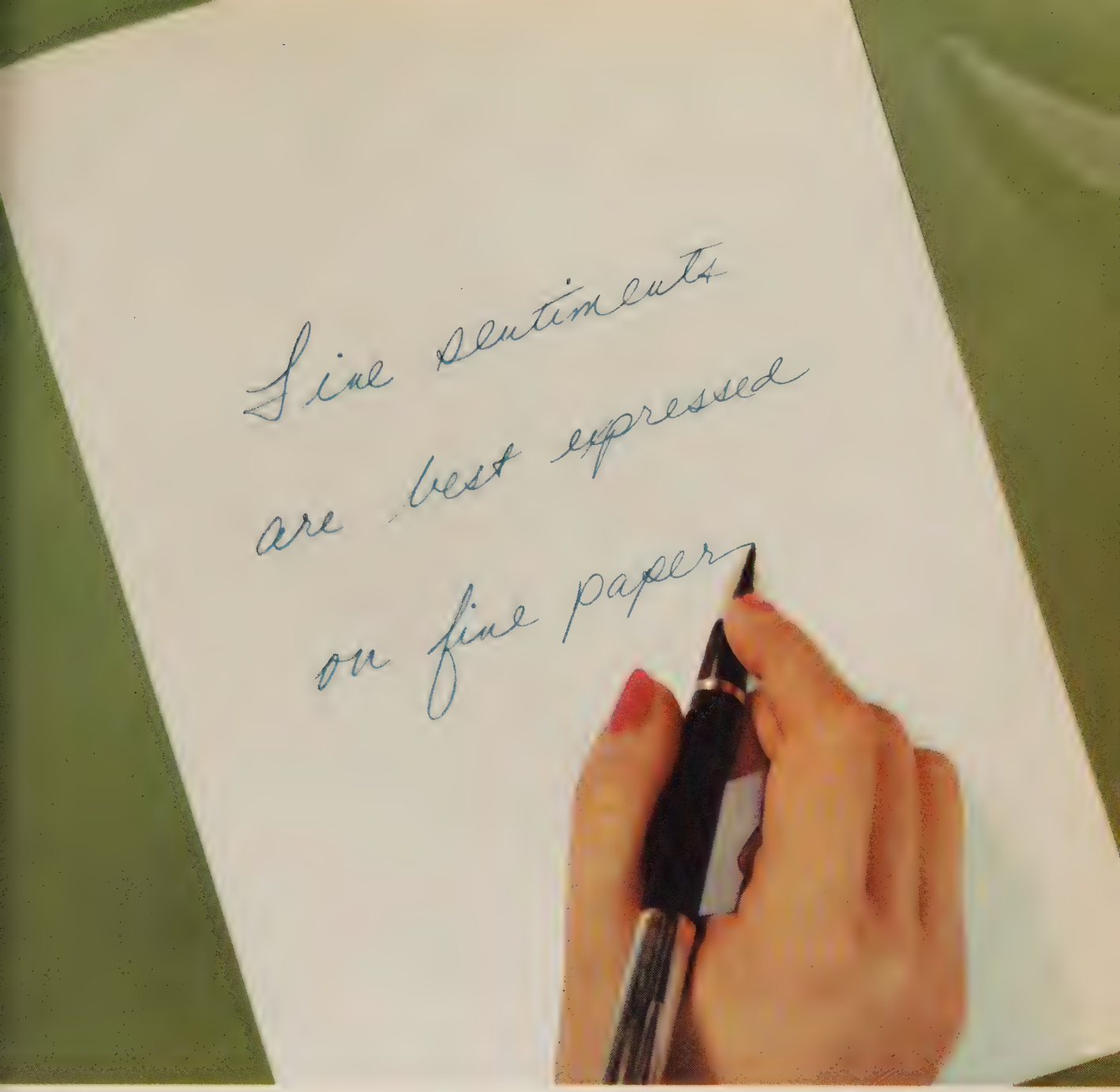

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Papers Presented at the Food Additives Panel

Empire State Section Meeting

Whiteface, N. Y., June 9–11, 1960

Food Additives Amendment Problems of a Packaging Material Manufacturer

C. R. CALKINS

I AM very pleased to have been invited to be here and to be a part of this program. However, I am a bit worried that what I may have to say will be somewhat redundant and really cover the same ground in a far less authorative fashion than the other speakers on the program. The only real excuse to have me here is that the orientation of this talk will be on the mechanism of handling these problems, rather than the problems themselves.

Riegel is probably fairly unique in the number of areas that are concerned with food packaging.

We are manufacturers of glassine and greaseproof which is sold to many converters who carry out various operations ending up in food packaging materials for the food industry. While, of course, we cannot be responsible for their further treatments, we do have a legal and moral responsibility to see that the materials we supply them are both actually and legally safe.

We are printers of glassine, greaseproof and other grades by gravure and flexographic printing, we do waxing and wax laminating, solvent coating, polyethylene extrusion, glue laminating and related operations, and various combinations of these, almost exclusively for the packaging industry.

We sell pulp to people who use it for food packaging grades and we are manufacturers of coated bleached board.

We have a carton operation in which we print and manufacture cartons primarily for meat and food packaging.

We also do some converting of films which gets us involved into certain aspects of nonpaper materials.

While we have never had formalized procedures, the matter of toxicity and potential harm to the ultimate consumer is a problem that has always been with us. In some cases our customers, particularly among the larger food packagers, have always been concerned and have reviewed with us at various times what we do and why. Beyond this, we have sincerely tried to be fully satisfied that nothing we use could be of any possible harm.

I might also say, speaking for myself and for Riegel, the intent and purpose of this law is quite welcomed and acceptable. The principal problem has been to obtain, evaluate, and properly present to F.D.A. all the information necessary to a truly accurate judgment of potential hazards. (The amounts involved in packaging material potential transfer are a different order of magnitude than intentional food additi ves.)

When the publicity about the approaching passage of the law and the final passage of the Food Additives Amendment in 1958 took place, we immediately took a number of preliminary steps.

First of all, we obtained copies of the Amendment and quickly available legal interpretations. Our staff legal counsel took various steps to obtain the fullest possible background information concerning the Amendment. Those of us concerned studied and discussed the Amendment and tried to visualize just how the situation should be handled.

We made arrangements to visit the Food & Drug Administation people for preliminary discussions. We were placed on their mailing list so that we would be up to date on all available material. After we had gone through this preliminary phase, we then took a series of steps to reduce this general picture to specific action.

1. We realized that this was an important problem and one member of our management was selected to have final responsibility for the entire company.

We also selected one technical man to devote his efforts full time to this problem, including obtaining and correlating information and becoming our internal nonlegal expert in the matter. We made arrangements for a member of the Purchasing Department to have responsibility for contacting suppliers and formalized a system of doing this.

2. We tabulated exactly what we were doing both qualitatively and quantitatively and organized it in a manner suitable for review by various people in our organization. This was a much larger job than you might imagine. We make literally hundreds of different grades and many of them are extremely complex materials. However, we did this by dividing the company into groups—glassine and greaseproof, converted products, board products, cartons, and miscellaneous.

3. We contacted all our suppliers and reviewed with them what we were doing and how, and obtained all the information about the material and its use that they had, or were willing to share. In many cases trade secrecy, particularly in the areas of minor additives, slowed down the development of factual information.

4. We realized we were not as competent as we needed to be in this field and decided to hire a consultant. We did some preliminary investigating and obtained the services of one of the numerous able consultants in this field on a retainer-basis. I might say this turned out to be one of the wisest moves we made, because it enabled us to fill numerous gaps in our knowledge, it enabled us to know areas that might be potentially difficult, and it enabled us to know many areas that we had nothing to worry about. Our consultant was given copies of all our organized work and access to every bit of information we had.

5. Simultaneously with a number of others we began to realize the value of a group approach wherever possible. The Glassine & Greaseproof Manufacturers Association which of course was an important part of our problem, set up a committee to review those problems with common interest to the entire industry. In addition, National Paperboard Association and American Pulp & Paper Association set up a more general joint program of which you will hear more about later this morning and I will not touch on it further, except to say I think they did, and are doing, a wonderful job. Also, the National Flexible Packaging Association, and numerous supplier associations set up similar committees.

6. We made a basic decision to offer the cooperation of our people in any industry-wide effort. As a result members of

C. R. CALKINS, Director of Research and Development, Riegel Paper Co., Milford, N. J.

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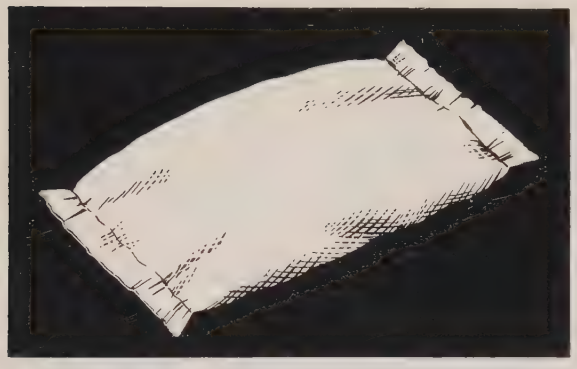

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the Riegel organization have or are now serving as members of the Toxicity Committee of the Glassine & Greaseproof Manufacturers Association, on the National Paperboard Association-American Pulp & Paper Association joint committee, as a member of the Food Protection Committee of the National Research Council, as a member of the National Flexible Packaging Association Toxicity Committee, and have been ungrudging regarding use of our people in any industry-wide educational or information exchange type of program.

Philosophically, we also came to several basic decisions. First of all, in spite of all the work of committees and the like, we made a decision that we would be prepared to stand alone and protect ourselves and our customers no matter what happened industry-wide. Secondly, we made a decision that we would be willing to share information in this field with other people, feeling that in the long haul any problem or unfavorable publicity would reflect upon us as well as someone else who knowingly or unknowingly violated the law.

As the program shaped up, we found out some of our weak points and we made some changes in our practices, and we tentatively prepared to make others depending on what happened in the field of clearances and extensions.

In some cases we merely made some changes because it was simpler to do so and use an approved material against an unapproved or unknown material without much trouble (and in some cases inventory simplification).

In other cases we had some problems in that we were not always sure of a substitute. At one time we were quite worried about the foam killer situation, for a number of reasons. In general, we did not know what was in our foam killers, nor were our suppliers willing to tell us. (Eventually in certain cases we worked an agreement where they would reveal the constituents to our consultants under a pledge of secrecy, and our consultants would give us advice as to whether we should continue use.) In this specific area we made extensive experiments with an approved defoamer in anticipation of shifting to it. As it is turning out, this problem will be no doubt worked out, but while we now do not anticipate a great crisis here, if one were to come we would be prepared.

In many cases we asked our suppliers to set up transfer tests. We did some transfer work in our own laboratories particularly of an exhaustive or excessive nature. This has given us a good deal of background into the potential possibility of transfer even under the most adverse conditions.

In general, however, we have regarded it as a supplier job to get his material cleared, and have done so only to the extent that we are dependent on the material, or that we needed better background ourselves.

After the various effects of the Amendment upon suppliers had varied from unrealistic fears, to thinking it would be no problem, back to a realistic evaluation, most of them cooperated fully. In a few cases, suppliers have not been particularly willing to do so. In some cases they have been tempted to withdraw the use of their products because the usage is so small, and they simply don't feel the product is worth it. This attitude tended to be more prevalent when people were talking of complete toxicity tests as a minimum. As it became apparent that transfer tests or shorter toxicity tests might be acceptable, depending upon the individual situation, this attitude seems to have practically disappeared.

Basically, the real remaining problem area, for us at least, has been in the field of minor additives. This has often resulted in a situation in which the manufacturer of the minor additive uses a very small amount of a particular raw material; we use a small amount of the compound, there is a large retention loss, and the packaging factors make the potential transfer extremely small. However, there has been a great deal of grayness in these areas and they have been the ones which we have been faced with the most crucial decisions.

Specifically in this area are the use of dyestuffs and particularly tinting dyestuffs. I will not touch further on this since you will hear a far more authoritative report later on the program.

How does the situation stand today as far as we are concerned? We have made some changes, in general, for legalistic reasons, but we are operating with a number of materials which are under extension, rather than clearance. We are continuing our program of working with suppliers and consultants and in preparing for the possible loss of some of these materials.

Specifically, you might be interested in how we handle our problems and our future problems. We have a white list of acceptable materials and suppliers. The Purchasing Department may not purchase any material that goes into paper or related products which is not on that list, specifically by material, trade name, and suppliers.

Additions to this list may be made only by written approval of several members of our organization. If a new product or a new supplier comes into our offices, before anything can be bought he must submit evidence that it is acceptable. An internal form is circulated which adds the material to the white list, when various approvals are obtained. In addition, we continually review our white list.

By this means we hope to eliminate the possibility of so-called "backdoor" selling and putting things into our mills that are not approved. No doubt like any system it will be revised and clarified, but so far it seems to be working fine.

To sum up, our experiences are probably common to that of all of you and my only possible reason for telling you about it is that we are deeper than most in it. We went through various stages of discussion and finally reached an understanding of the realistic premises and possibilities of the law, we reviewed what we are doing and have taken steps to insure that our practices are both safe and legal. No doubt there will be further problems, but I am fully satisfied that eventually the law will not be an excessive burden on our industry, and in fact, because it gives further assurance to our ultimate consumers, will be a boon to us.

Presented at the meeting of the Empire State Section of TAPPI, held in Whiteface, N. Y., June 9–11, 1960.

The Use of Colors in Food Packaging Paper

E. I. STEARNS

THE use of colors in food packaging paper, as far as coal-tar dyes are concerned, has been controlled by law ever since the 1938 Federal Food, Drug and Cosmetic Act. However, the Food Additives Amendment of 1958 has brought new attention to the problem of all incidental additives. Paper mills are seeking reassurance that they are within the 1938 law and are preparing for rapid compliance with the proposed Color Additives Bill.

In reviewing the color problem today, there are certain assumed principles on which the following discussion is based. The first of these principles is that the use of color is a necessity in modern day merchandising. In theory, it would be possible to leave dyes out of paper entirely, but if this were done, it would not be long before some enterprising firm added dye to its food package to make it more attractive and saleable. When others found that their sales were suffering, they, too, soon would be adding dye in order to share in the market.

The second underlying principle is that the dye manufacturers and the papermakers want to protect the public health. I think there is no argument against this statement. The tremendous strides made by the packaging industry in protecting and preserving food and therefore helping the public in its health problems is evidence of this fundamental desire.

The third principle is that the dye manufacturers and papermakers want to conform to all requirements of the law. Again, I believe this needs no elaboration. There may be

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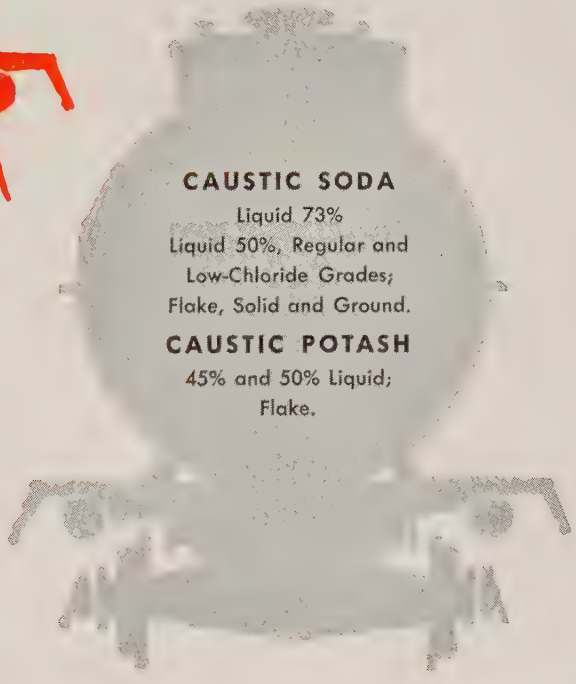

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some who wish to get by with slight infractions which they hope will be overlooked, but this discussion is not prepared with these people in mind.

A fourth guiding principle in preparing this talk was that if a papermaker wants legal opinion, he will hire a lawyer and will not use this article as legal counsel. My company is in the business of manufacturing and selling dyestuffs and is not in the law business.

The fifth assumed principle is that no one wants to use the F.D.A. problem as a means of gaining a competitive advantage. This is perhaps the most doubtful assumption, but I would like to point out that it is much more economical in time and money for all of the paper mills to pool their color problems and have them solved on an industry-wide basis than it is for each mill to solve its own problems. It is also a recognized principle of our government that we wish to support small business and prevent the growth of monopolies. If a large mill is able to spend the money to clear the use of dyes in their products and use this as a weapon to force small mills out of business, I am sure that most people would consider this an abuse of the F.D.A. laws. I also understand that the Food and Drug Administration is sympathetic to the proposal that as many problems as possible be solved on an industry-wide basis because this would permit a more rapid assurance of compliance with the law and would involve much less work for them.

A review of the laws as they apply specifically to color is in order. The various laws controlling the use of color are complicated by the fact that we have three different kinds of color and three different existing or impending laws. The first group of colors, and the ones which find the widest use in food packaging paper, are the uncertified coal-tar dyes. According to the 1938 Federal Food, Drug and Cosmetic Act, uncertified coal-tar dyes must not transfer to food from packaging materials. The Color Additives Bill which is now pending in Congress is identical in this respect. There is one difference in burden of proof which is of importance to the paper mill because under the 1938 law the government must detect the migration of dye to the food before they can condemn it, whereas, under the proposed Color Additives Bill, the government may ask the producer to prove to their satisfaction that no migration of color will occur. The Food Additives Amendment of 1958 does not apply to this class of color. Some of us think that this 1958 law should be changed so that it is made applicable to color and, in this case, the criterion would be there must be no more migration than has been proved harmless.

The second group of colors are the certified coal-tar dyes. According to the 1938 Act, these dyes may transfer to food to any extent and the batches of color are taxed in that the payment of a fee is required for each certification. Under the Color Additives Bill, which is pending, certified dyes may not migrate to food more than a tolerance which is fixed by law consistent with the rigorous protection of public health. These batches are also taxed. There is no such thing as a certified dye in the Food Additives Amendment of 1958.

The third group of colors are the noncoal-tar colors. In the 1938 Act, there is no regulation of these colors. In the Food Additives Amendment of 1958, there is permitted no more migration than has been proved harmless or is considered safe. By June 10, 1960, there were six colors other than white which were considered so safe that an extension on their use was granted to March 6, 1961. These six colors are the following: burnt umber, carbon black (channel process), chromium oxide green, iron oxides, raw sienna, and ultramarine blue. Under the proposed Color Additives Bill, the noncoal-tar colors would be divided into two groups—the uncertified noncoal-tar colors must not transfer to food, and the certified noncoal-tar colors may not migrate more than designated tolerance consistent with the rigorous protection of the public health.

There are some added complications. For example, it may be at the discretion of the Secretary of Health, Education and Welfare whether a particular component is to be considered as a food additive or a color additive. Also, we are not quite sure of the final form of the Color Additives Bill. Ignoring these complications, and at the risk of oversimplification, these legal aspects are summarized in Table I.

Table I. Applicability of Law

	Uncertified coal tar	*Certified coal tar*	*Noncoal tar*
1938 Act	No migration	May migrate to any amount	No regulation
1958 Food Additives Amendment	Doesn't apply	Doesn't apply	May migrate to legal tolerance [a]
Color Additives Bill	No migration	May migrate to legal tolerance	

[a] Under the pending Color Additives Bill, a noncoal-tar color, if certified may migrate to a legal tolerance and if not certified, may not migrate.

It is interesting to speculate upon the differences that will be introduced if the Color Additives Bill becomes law as it is now written. With reference to the vast majority of colors used in packaging, uncertified coal-tar dyes, there is no difference since no migration may occur under the new law. The significant differences all apply to certified colors. The first difference is that noncoal-tar colors will not be differentiated from coal-tar colors. A second difference is that the use of certified dyes will be restricted since the amount migrating into food will be limited to legal tolerances. A complication is that analytical tests must be devised to measure precisely the quantities present in foods. A third difference is that some additional coal-tar dyes may be certifiable. Under the present 1938 act, a dye must be proved harmless in any amount before it is certifiable. Under the proposed Color Additives Bill, it is possible to certify a dye if it is proved to be harmless when used within prescribed limits.

Some of us think that the Color Additives Bill is not necessary and that the Food Additives Amendment should be made applicable to all colors. If this were done, the public health would be protected just as well and the only difference would be that permissible migrating dyes would not be discriminately taxed.

In view of the increased attention to existing law and the pending changes, just what problems do the dye manufacturers and paper mills face? The answer is, prove nonmigration of color. It does not matter which law applies. Toxicity data are so expensive that they are not likely to be obtained on new colors. Without toxicity data, the 1938 law requires there be no migration. The Color Additives Bill says there must be no migration and if the Food Additives Amendment is applicable, there must be no migration. Therefore, proof of nonmigration is essential in any case.

This problem and its solution has become clear to all concerned. The paper mills have appointed a special Dyes Subcommittee of the Joint Food Additives Committee of the American Pulp and Paper Association and the National Paperboard Association under the able chairmanship of R. C. Crain. Most of the dye manufacturers are members of the Synthetic Organic Chemical Manufacturers Association. This association, SOCMA, has appointed me chairman of the dyes *ad hoc* subcommittee of the Food Additives Committee to assist the paper mills in getting Food and Drug Administration approval of the use of dyes in papers for food packaging. These two committees have been working closely together.

The APPA-NPA committee sent out a questionnaire on April 12, 1960, to all the paper mills inviting them to send in their color problems. When these questionnaires are received, the information will be coded so that the name of the paper mill is not revealed and then will be discussed with the SOCMA committee. Working in close cooperation with

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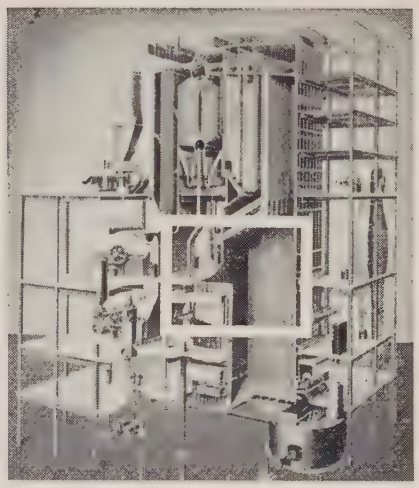

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the Food and Drug Administration, it is expected that this problem can be reduced to a manageable size by certain generalizations and that satisfactory analytical techniques can be worked out.

For example, one of the largest groups of papers is white paper but this, of course, is not undyed. White paper ordinarily contains both fluorescent bleaching agents and tinting blues. This type of paper is represented by so many specific products that our first attempt in the questionnaire will be only to determine which dyes are used, then we will select sheets of paper containing these dyes in the highest concentration at which they are used in whites. After we test these commercial sheets of high concentration of dye and find that they are satisfactory for migration, we would hope to get official sanction for the manufacture and use of all whites containing smaller amounts of dye.

The classification of color grades will be a more complex problem but the same principle will be applied, namely, if Safranine is used in butcher wrap, we will try to select the commercial butcher wrap with the highest concentration of Safranine and by demonstrating that this heavily dyed sheet is satisfactory, we would hope to clear Safranine at all lower concentrations, certainly in all butcher wraps, and possibly in all other food applications where edible fats was the primary exposure. I cannot predict just what generalizations we will attempt to make but the above will give you some of the thinking as we try to clear up the dye problem.

We have been keeping the Food and Drug Administration closely informed of our plans and activities. On April 19, 1960, representatives of both APPA-NPA and SOCMA committees met with F.&D.A. officials and discussed our preliminary dyes migration data and other technical features.

I expect that technically the problem is capable of solution by proper selection of dyes and manufacturing procedures and I would like to discuss next with you some of the properties of dyes that lead me to believe that a solution can be found.

The following discussion gives a summary of what might be expected from various classes of dyes in paper in contact with various classes of foods although any such general discussion is somewhat misleading because of the many exceptions.

The common paper dyes are grouped into four classes—pigment, direct, basic, and acid dyes. Pigment dyes are insoluble in water. Direct dyes are substantive to cellulose. Basic dyes are substantive to the lignins and related materials present in unbleached pulp. Acid dyes are retained on paper in the presence of alum and size.

There are many food exposures of paper. In our discussion with the Food and Drug Administration, they have indicated that migration data into food can usually be simulated by migration into the appropriate liquid as described in a recent paper by Ramsey. These liquids we refer to as the seven Ramsey solvents which are the following:

1. Distilled water.
2. 3% sodium chloride solution.
3. 3% acetic acid solution.
4. 3% sodium bicarbonate solution.
5. 20% sucrose containing 1% citric acid at pH 3.5.
6. Lard oil.
7. Aqueous ethyl alcohol.

The following table shows *very generally* the suitability of classes of dyes for food uses.

	Dyes for Food Packaging Paper (Numbers Refer to Ramsey Solvents)		
	Good	*Doubtful*	*Very doubtful*
Direct	1, 2, 3, 5, 6, 7	4	...
Basic	1, 2, 4, 6	5	3, 7
Acid	6	2, 5, 7	1, 3, 4
Pigments	1, 2, 4	3, 5, 6, 7	

Direct dyes vary in substantivity but many are expected to be satisfactory. They are made more soluble in the presence of alkali and therefore are listed as doubtful in solvent 4. Since they are all sulfonated, they are expected to be quite insoluble in lard oil.

Basic dyes are more soluble in the presence of acid and are quite soluble in alcohol. Therefore, they are rated very doubtful in 3 and 7. Possibly the high concentration of sucrose would reduce the tendency to migrate in solvent 5, but the basics are no better than doubtful in this solvent.

Acid dyes have good solubility in water which is reduced by the presence of other dissolved materials such as salt and sugar, but only in an organic solvent such as lard oil would they be expected to be satisfactory.

There is so much variation in pigments that a generalization is not too useful. Pigment Violet 3 and Pigment Blue 5 are lakes of basic colors and are not stable to acid or alcohol. When the lake is destroyed, there is a greater chance for migration to occur if the concentration is large. For this reason, pigments in general are called doubtful for solvents 3, 5, and 7, although some specific pigments are satisfactory. Because Pigment Yellow 1 and some other organic pigments have some solubility in lard oil, pigments are also rated doubtful in 6.

All of the above discussion assumes good manufacturing practice in making the paper. The retention of pigments is better if the concentration is on the low side and the amount of size and alum is on the high side. The retention of direct colors is better at higher beater temperatures, longer beating time, and with the addition of fixatives such as Cyanamid's Parez Resin 607 or Nalco 600 of Nalco Chemical Co. The retention of basic colors is better if the pulp contains some unbleached component. One general indication that the mill men can use is the color of the back water. If this is white, the dye is pretty well fixed and chance of aqueous migration later is lessened.

In view of the above technical properties, it is expected that the cooperative work of APPA-NPA and SOCMA will indicate many acceptable dye usages. But even if this work should "clear" the use of a dye, there will be no guarantee that food can never be seized and condemned for contamination by dye. The committee work may indicate that a certain dye is satisfactory in a certain kind of paper for a certain end use, but if the paper is not made in accordance with good manufacturing practice, there may be some migration of dye and hence, violation of the law in a particular case. It is expected, however, that conformance to the recommendations which the APPA-NPA will make after the study is completed will give a very good probability of compliance with the law.

It should be remembered that coal-tar dyes, which are the major factor in coloring paper, are presently controlled by the same law which has applied for 22 years. However, the House Interstate and Foreign Commerce Committee began Thursday, May 19, in executive session, its formal consideration of color additives legislation, H.R. 7624 and S. 2197. The problem is so complex that the paper industry will need a running start for compliance with the color additives legislation when passed.

Presented at the meeting of the Empire State Section of TAPPI, held in Whiteface, N. Y., June 9–11, 1960.

The Seas Grow Calmer

JOHN L. HARVEY

Last summer and fall, I and members of the food additives staff of the Food and Drug Administration were engaged in making a number of talks, both formal and informal, to groups in the packaging industry. Among the groups involved was TAPPI. I recall that Mr. Checchi, who was at the time my assistant, met with you last September.

It goes without saying that the subject was the Food Additives Amendment to the Federal Food, Drug, and Cosmetic

John L. Harvey, Deputy Commissioner, Food and Drug Administration, U. S. Department of Health, Education, and Welfare.

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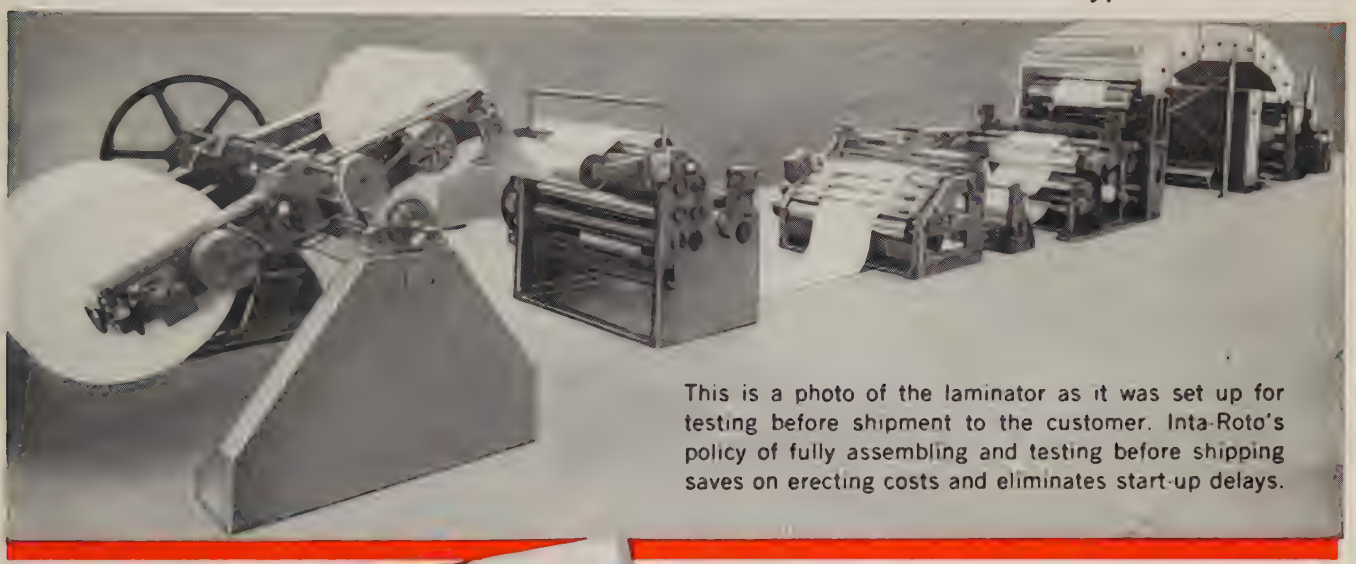

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Act and our prime purpose during those months was to try to offset the cries of "crisis" and "panic" which had been heard ever since the realization that the Food Additives Amendment referred to "indirect additives" and would have a definite effect on many food packaging items. We had heard many stories to the effect that it would be impossible not only to comply with the law but to acquire sufficient basic information about possible unsafe migrants from packaging materials to enable an intelligent evaluation of just how the law would apply.

We were even told that once this law went into effect, it would have the inevitable result of returning the food marketing business to the old cracker barrel days; that even the sanitary benefits of food wrappings would be lost. Unfortunately, for a time it began to look as though we were just one small voice in the wilderness in trying to achieve a rational approach to the problem. The attitude of "it can't be done" continued in some quarters until early in 1960 when several groups from the packaging industry approached members of Congress, in some cases emphasizing dire predictions of the terrible state that the food packaging industry would be in on March 6, 1960, unless something were done to prevent this law from becoming effective.

As you all know, the law itself carried a provision authorizing administrative action to extend its effective date for up to one year on a showing that the extension was necessary and would present no undue hazard to health. But there were some who seemed to feel that this was not a rational approach to the problem. They preferred to try to get Congressional action to extend; although I must say that, in some cases, extension for only one year was the furthest from their thoughts. There were those who thought that the effective date should be extended, as far as packaging materials were concerned, until sometime far in the future when the whole thing might be forgotten.

The members of Congress who were approached made careful inquiry as to the facts and advised those importuning them for legislative action that they were knocking on the wrong door; that the Congress wanted to see the law administered in the way it was intended when enacted back in September of 1958.

I think that was the real turning point as far as attitudes about the Food Additives Amendment for packaging materials was concerned. There was an immediate about-face and I would like to just run over what happened as far as paper materials were concerned.

From the halls of Congress the representatives of the paper pulp and paperboard industries came and sat down with us with the attitude that if they must do so, they would undertake to try to convince us on an individual basis that the chemicals used in the paper and paperboard manufacturing operation were of such character and were present, if at all, in such amounts as to present no undue hazard to the public health if their use were continued for another year.

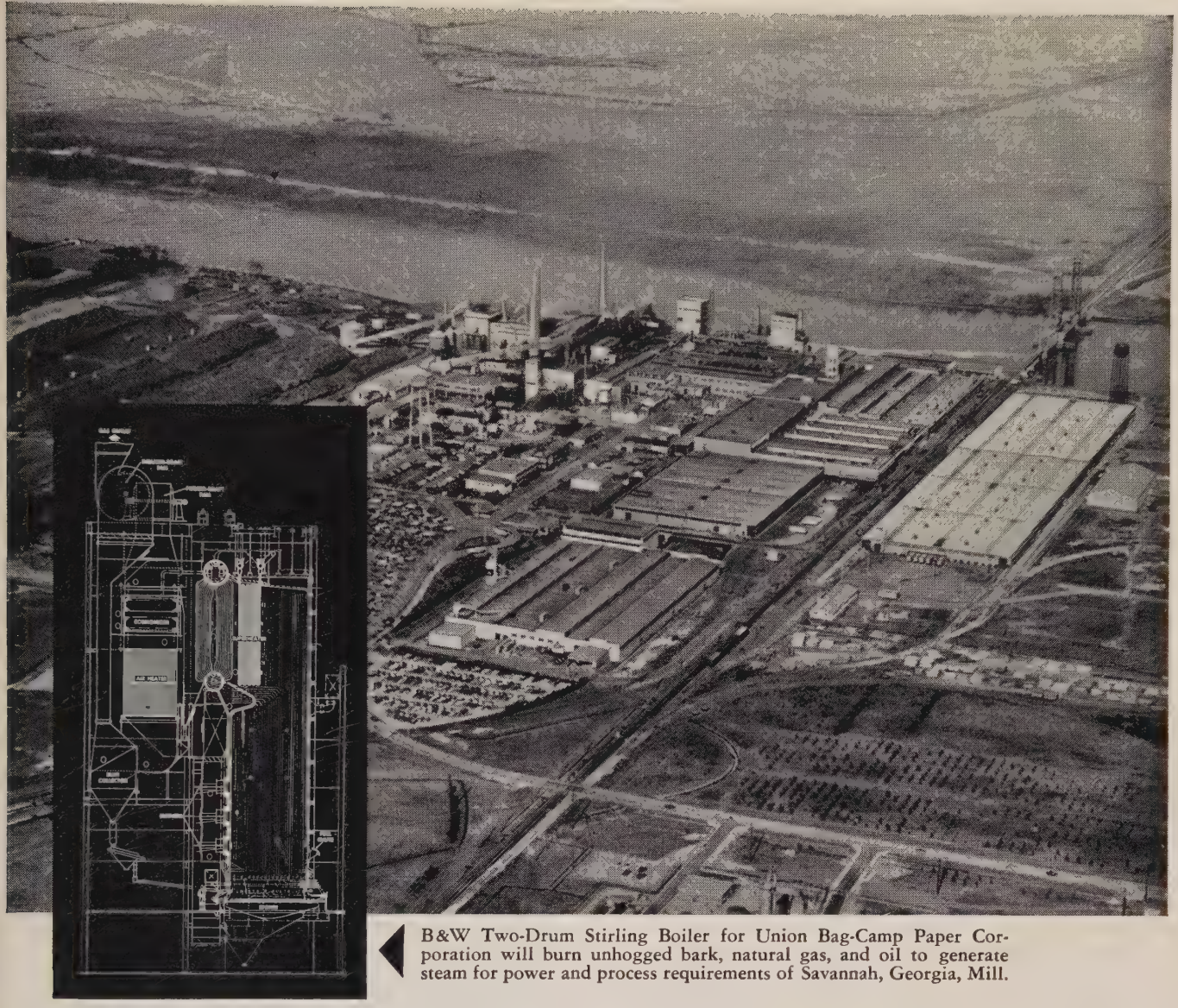
The industry group and its technical people rapidly got together a tremendous amount of information in this field. We, for our part, made available our technical staff to sit down with the group and go over each item so that an evaluation of its status could be made solely on its own merits in the light of this great amount of background information. The result of this was the publication in the Federal Register of status lists for these materials used in making paper and paperboard packages, this being under date of March 1, 1960.

We were able without difficulty to classify 67 items as being in the category of substances generally recognized as safe. As far as those items are concerned there would be no food additive problem presented whatsoever nor would we anticipate any other difficulty with them as long as they do not carry harmful impurities which, of course, would put an entirely different light on their suitability for use where migration to the food might occur.

At that time also, we were able to announce a list of 28 groups of substances which had prior sanction for use in food packaging materials and here again this served to remove those items from the food additive category. This left 134 covering defoaming agents, rosins and rosin derivatives, and a number of miscellaneous chemicals which could not immediately be placed in either of the other two categories and thus were classed as food additives. For these items, the Commissioner was able to conclude that their continued use as in the past in food packaging would not for the next year present any undue hazard to the public health.

I think I should at this point take time to mention that over the years we had expressed some concern over the use of certain chemical agents in papermaking where we thought there might well be some hazard if they carried through to finished food packages. Not one of those substances, such as the mercurial slime preventive items, was presented to us for consideration under the extension procedure; instead we were informed that evaluation of the matter had led the industry to conclude that it should not continue the use of such highly toxic substances where the paper and paperboard being manufactured was to come in contact with food. This was a very gratifying development.

The list of 134 items on the extension list may at first glance lead some to believe that we are going to have to have 134 petitions for formal regulations covering these substances prior to March 6, 1961. We in the Food and Drug Administration do not think that this is the case and I am sure that the technical people of the industry are of the same view. Some of the items on the list are also used as direct additives to foods and I expect that those concerned with that type of business will see to it that appropriate petitions for regulations are presented and no doubt can be evaluated not only as direct additives but as migrants from the packaging materials.



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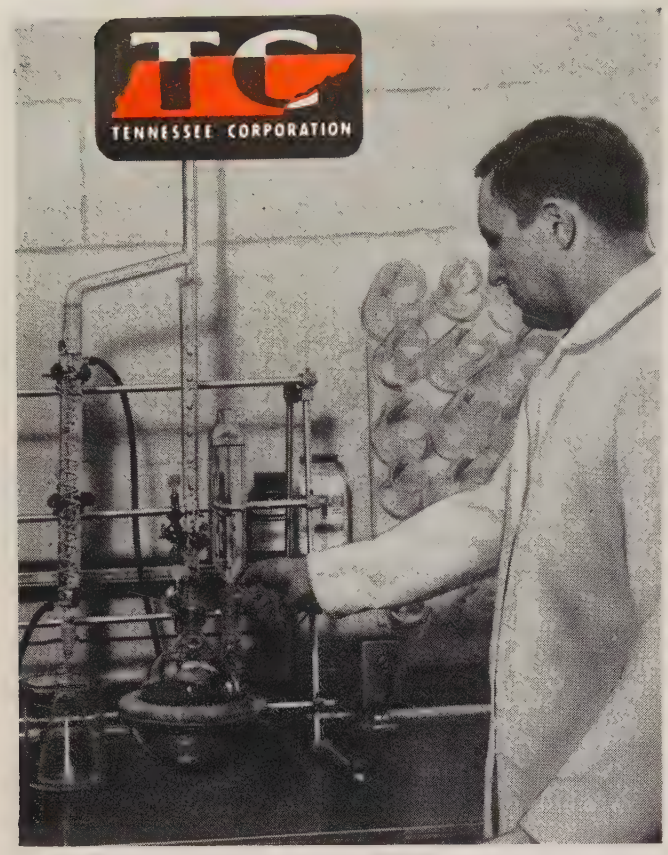

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Examples in this group would be the stearic and oleic acid products and some of the polyethylene glycol items. Then too, and perhaps more important, is the question of whether or not certain of the items on this list actually migrate to foods under ordinary conditions of use. This, as you know, is something which can be determined and I understand from reports by our technical people that your industry is actively engaged in getting the facts along these lines. Undoubtedly there will be migration of some of these substances which will call for food additive regulations. I can only urge that you get the basic information necessary at the earliest possible moment and get the petitions in to us in good season so that we can act upon them prior to the March 6, 1961, deadline.

I think all concerned fully realize that there is no provision in the law for additional extensions beyond that date.

The enactment of the Food Additives Amendment brought into contact with the Food and Drug Administration members of quite a few industries which heretofore had considered that they had little if anything in common with us. While not exclusively so, as would be readily apparent from the prior sanctions we granted in this field over the years, many members of the paper and paperboard packaging industry were in this category. I really believe that much of the insecurity and feeling of uneasiness which was so manifest last year was basically the result of misinformation and misunderstanding.

I suppose it is not unreasonable to expect such a feeling when there is such a fundamental lack of understanding. It is completely apparent to me, however, that during recent months this situation has been cleared up. We see more and more published articles which urge steps be taken to comply with the law and which offer suggestions as to how this can be done most readily. This is a real improvement over the scare headlines we saw last year.

There is no disposition on the part of the Food and Drug Administration to believe that the problems presented in evaluating products from the standpoint of the Food Additives Amendment and in taking proper steps to comply with that amendment, are simple. We know that you have had your problems and I think that many of you who have had contact with us know that we have ours too. As we get to know each other's problems, however, they do somehow get solved easier on a fully cooperative basis with no holding back on the part of either group.

It is because of this realization of the facts of life and of the other fellow's problems that I chose the title for this paper—"The Seas Grow Calmer." Surely we are not yet in port. There is much to be done and perhaps the worst mistake that could be made in this field would be for people in industry to feel that the extension list of March 1 solved all their problems. That list represented a real forward step, but it does have a time limitation.

I can give you our assurances that if you people do your part in getting together and submitting the basic information necessary for any needed regulation, we will do everything we can to see to it that this is evaluated on a scientific and, at the same time, sympathetic, basis.

Along this line, I understand that some have expressed concern about getting any regulations which may be necessary for package migrants because of the possibility that methodology may not have progressed to the point where it is possible to determine the presence of the migrants in various food products except on an experimental basis using, for example, the radioactive tracer technique. Admittedly, we are not going to work in a vacuum and have no intention of issuing regulations under the Food Additives Amendment without a sound means of enforcing them.

Certainly, however, there is more than one approach to this problem and we stand ready to consider any reasonable proposals which are offered. Of interest on this line is the action which we took dealing with the polypropylene food wrapping material. There we had a situation where experimentally we could determine just what migrated, and how much, but on a

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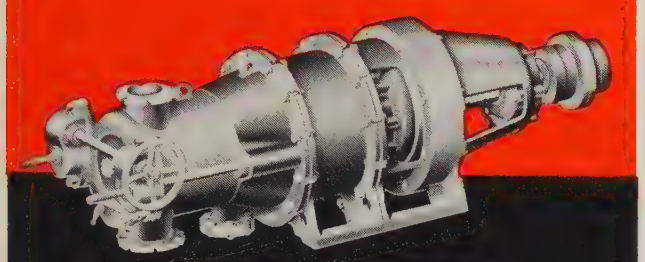

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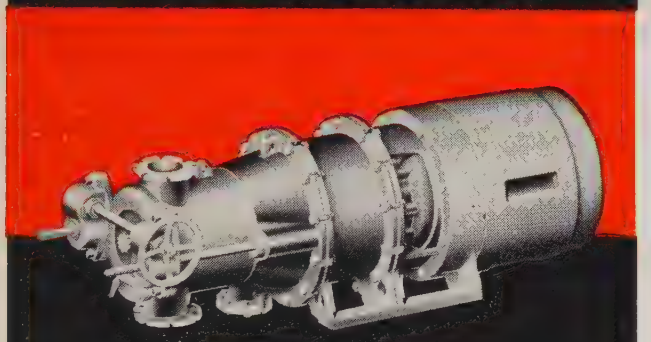

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commercial basis there was no way by which we could analyze a food which had been wrapped in polypropylene and find out how much of the polypropylene was actually present in the market sample.

The specification approach was proposed and after evaluation and study, we found this to be quite feasible. We therefore issued a regulation authorizing the use of polypropylene provided the polypropylene itself met certain specifications. A check of the polypropylene will tell whether or not it is the substance covered by the regulation and if it is, then its use is fully authorized.

We now have under consideration a comparable approach in another area of packaging—the can liners—and we do not close the door to this approach or some variant of it in other fields.

We are not just trying to be technical. We have a job to do which is, fundamentally, to protect the consumer. We are dedicated to do that job in the best way possible and yet, at the same time, we will not take any position in the administration of this food additive law which is not designed to achieve that objective.

Presented at the meeting of the Empire State Section of TAPPI, held in Whiteface, N. Y., June 9–11, 1960.

Food Additives Amendment and Paper Packaging

RALPH T. RUSSELL

So MANY questions were asked last evening concerning the role of Syracuse University Research Corp. and the Food Additives Amendment that I would like to take just a moment to review our organization and the work that we have been doing.

Our group was originally established in 1946 under the auspices of the Plant Sciences Department of the College of Liberal Arts. In the beginning we had two distinct but related programs. One program was conducted for the manufacturers of cups and containers and consisted of three phases, the first of which was the microbial testing of samples to see that they were sanitary, the second was an annual sanitation inspection of each plant, and the third had to do with toxicity. The two basic reasons for having the program for this group was to enable manufacturers of cups and containers to make sure that they practice what they preached, namely that their products were sanitary. The second was to gather data concerning the microbial aspects of the package that could be viewed by any public health officer if it was necessary to convince him that the products were acceptable. The toxicological aspects of the program were limited mostly to an evaluation of the products for germicide residuals, although some members attempted to get toxicity data on all the products they used. The program was very definitely a selfpolicing program.

Another important phase of the paper industry program carried on at our laboratories for the past several years has been that supported by the NPA. In the beginning this included a program of investigation, research, and services on the microbiological problems of mills. Studies were conducted to gather information for member mills on the economic significance, identification, characteristics and control of troublesome microorganisms found in paper mill systems. Top priority was given to projects related to putrefaction and odor problems in pulp and paperboard. Services included the examination of samples sent in by member mills for microbial examination. These samples included such diverse items as board samples, slime deposits, pulps, coating materials, and any item representing a particular problem to the mill and related to microbiology.

RALPH T. RUSSELL, Syracuse University Research Corp., Syracuse University, Syracuse, N. Y.

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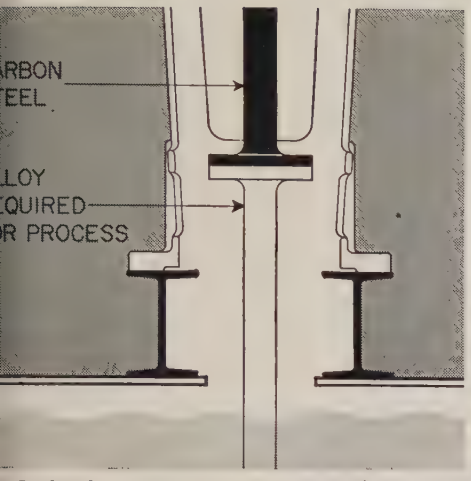

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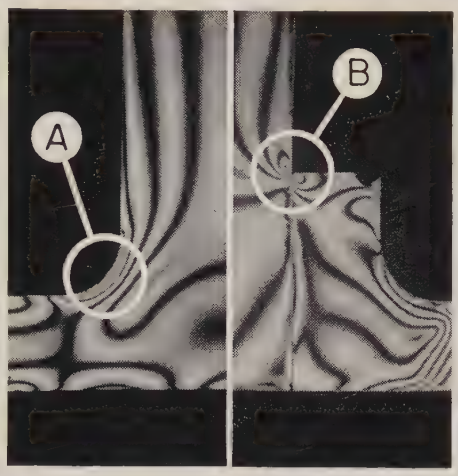

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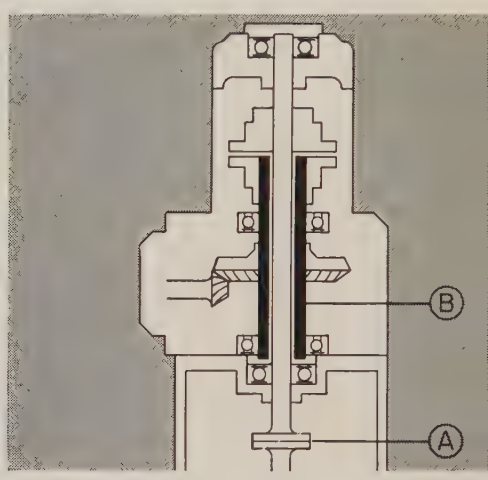
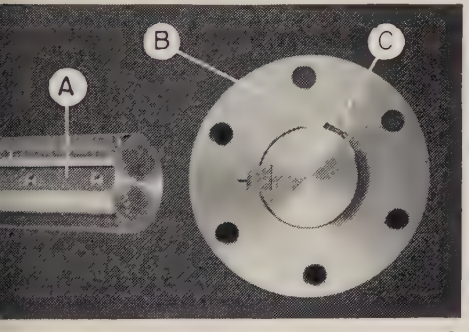


3. No need to disturb gearing if you ever want to replace a LIGHTNIN shaft. Lower shaft is unbolted at (A). Upper shaft slides out of hollow reducer quill* (B). Gears remain untouched—cannot get out of line. When new shaft is installed, shaft alignment is automatic. *Patented



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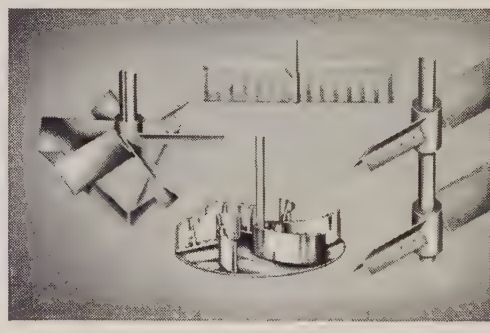

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The member companies could also request and receive mill services, including slime control surveys. Even at the outset, the staff was engaged in holding seminars, providing speakers at sectional and national meetings, providing short courses in microbial techniques for mill personnel, organizing instructional displays, and in general disseminating the rapidly increasing knowledge we were gathering from our expanding services. From the very first, members of the industry were constantly informed on matters effecting the quality of food packaging items.

From our early microbial investigations, our program for the NPA expanded into many other fields which concerned the industry. Certain germicides and paper processing chemicals were tested and the knowledge gained applied to mill sanitation problems. A nomenclature system was developed for identifying the various types of paperboard odors. Improved methods for use in the organoleptic evaluation of paperboard samples were developed. An organoleptic panel was organized and utilized on problems sent in by member mills. The nature of one of the most universal paperboard odors has been identified and mill control measures developed. Colorimetric methods for the quantitative measurement of volatile and reducible sulfur has been devised and these methods have been correlated with new tarnish control measures.

The work was transfered from an academic department of the University to the Syracuse University Research Institute a few years ago and within the past year to the Syracuse University Research Corporation. This has permitted the expansion and development of a staff of scientists whose entire time is devoted to the solution of problems arising in the paper industry. We now have 24 full time analytical and paper chemists, biochemists, microbiologists, and a widely experienced toxicologist.

Through these programs the Research Center has accumulated an extensive background of information directly pertinent to every phase of paperboard products. This knowledge becomes particularly valuable under present conditions created by the passage of the Food Additives Amendment and permits our laboratory to advise and guide our clients through these rather difficult times.

We are continuing to assemble information relative to the toxicological characteristics of chemicals that enter into the fabrication of food packaging units. We review the status, under the law, of each and every component of our clients packaging materials. Individual papermaking formulations are subjected to critical examination and evaluated to prevent the inclusion of materials that might be considered objectionable under the Amendment. If, in our judgment, certain materials are questionable we will make suggestions for changes in formulation. I would like to make it very clear here that in reviewing all of these data we abide by all decisions of the Federal Food and Drug Administration insofar as the clearance of a product under the Food Additives Amendment is concerned.

We are in the unique position of being neither "fish nor fowl" in our role as a consultant for problems relative to the Food Additives Amendment. We must look at all sides objectively and impersonally.

The Amendment to the Federal Food, Drug and Cosmetic Act which was enacted in September of 1958 caused a major upheaval in the paper and paperboard industry. The utter confusion which was created by the enactment of the law is an occurrence in the life of the industry never before experienced. This was not caused solely by any particular group, but was the unfortunate consequence of misunderstanding on the part of the package producer as well as those charged with the enforcement of the law.

Let us briefly review the events of the past 20 months and clarify some of the misunderstandings and misconceptions that developed.

Despite statements by various members of the Federal Drug Administration, on numerous occasions, that the act defines a food additive in such a manner that it may include, under certain conditions, the various materials which enter into the food package; the paper industry refused for a long time to admit this fact.

The definition of a food additive, as far as the packaging industry is concerned, appears in section 201 of the Act and reads as follows:

> "This term 'food additive' means any substance the intended use of which results or reasonably may be expected to result, directly or indirectly in its becoming a component or otherwise affecting the characteristics of any food (including any substance intended for use in producing, manufacturing, packing, processing, preparing, treating, packaging, transporting or holding food: . . . if such substance is not generally recognized, among experts qualified by scientific training and experience to evaluate its safety, as having been adequately shown through either scientific procedures (or in the case of a substance used in food prior to January 1, 1958 through either scientific procedures or experience based on common use in food) to be safe under the conditions of its intended use: . . . "Safe" as used in this section has reference to the health of man or animal.

The definition states clearly that a food additive includes any substance intended for use in food packaging. If the intended use of the package could result, or could reasonably be expected to result, in a substance becoming a component of, or otherwise affecting the characteristics of, the food, then the components involved must be found safe. Safety of the component can be established either by scientific disciplines or by experience based on common use in food.

It is also clearly stated that any additive to food is unsafe unless its use is permitted under the terms of a regulation issued by the Secretary of Health, Education, and Welfare upon the filing with him of a petition as provided in the amendment.

So far as the paper food packaging manufacturer is concerned, if a substance was not commonly used and accepted as safe prior to Jan. 1, 1958, and the substance migrates to the food, that material may be considered a food additive and may not be used without authorization from the Secretary of Health, Education, and Welfare. These permissions are obtained by petition or by the issuance of a regulation from the Secretary of his own volition.

The problems of the paper industry are certainly understandable. An exact interpretation of the law gave the paper packaging industry 18 months to obtain information on thousands of chemicals that could be used in many different ways in a food package.

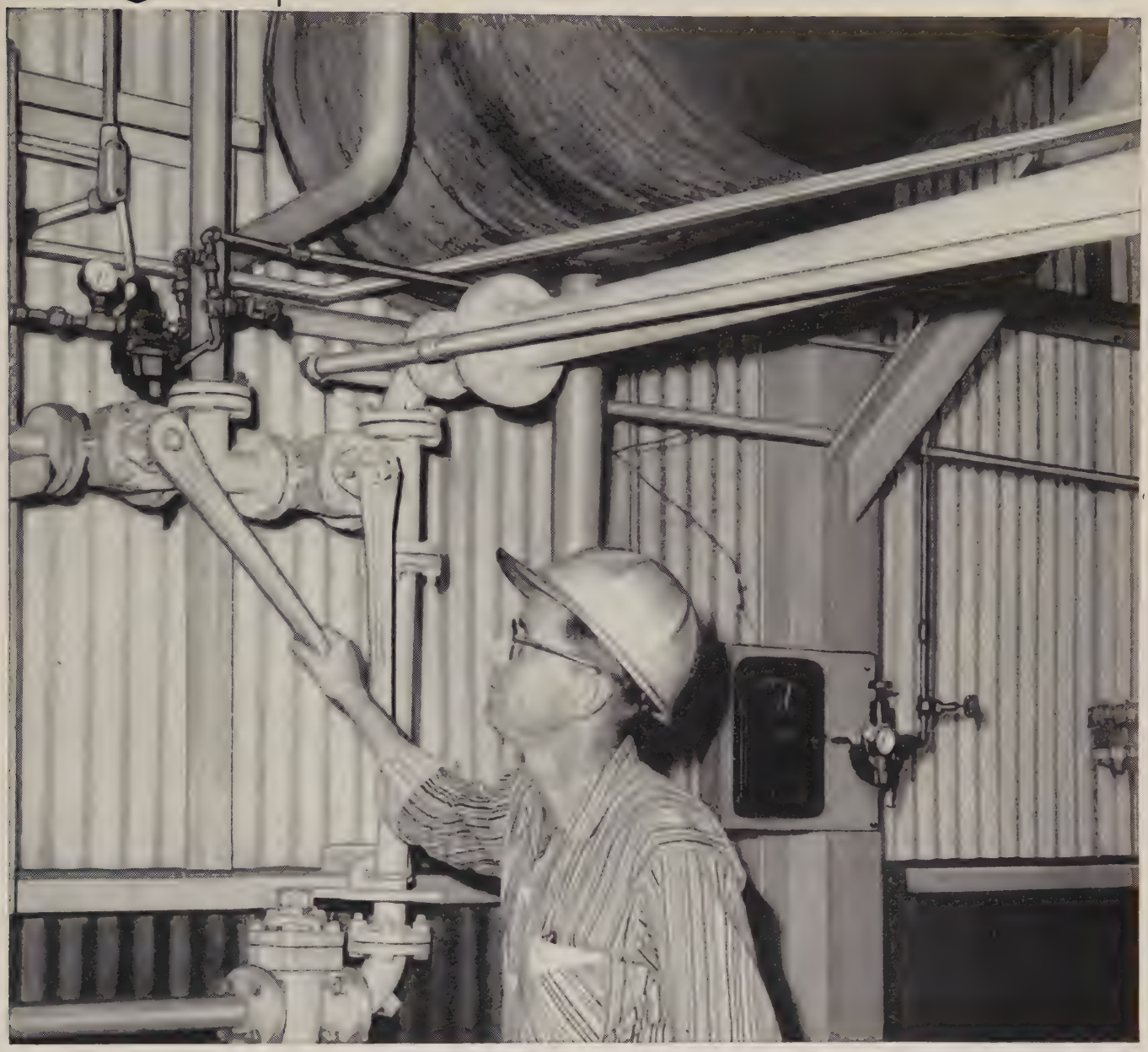
The paper industry was ill prepared for such a herculean task. Industry, in many cases, did not fully comprehend the extent of the law and the legal aspects of the act. In some instances poor advice was responsible for adding to the confusion.

There was also the uncertainty as to where the responsibility rested for obtaining clearances. Was it the responsibility of the supplier to obtain clearances or was it the responsibility of the manufacturer? Delay followed delay!

The time table by which the paper industry was allowed to produce the evidence of safety of the chemicals employed in manufacture was too unrealistic. We predicted, along with others, that it would take at least 5 years of concentrated effort to determine the safety of all the chemicals used by industry in the manufacture of paper packaging materials. Up to the present time, it appears that we may be right in our assumption.

Further delay was caused by waiting for the expected "white lists" to appear in official publications. Although a number of chemicals have appeared on the lists, a great many more have not. Since no one could predict with certainty what chemicals would be on the lists, it should be no surprise that further confusion was created. Certainly industry could not be expected to carry out studies to determine the safety of chemicals when those same chemicals might be exempted at a "near future date."

DOW | SARAN LINED PIPE



After 170,000,000 gallons paper-plant bleach . . .

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This is the delivery end of a saran lined pipeline which carries a corrosive solution of chlorine dioxide bleach, 24 hours a day, seven days a week. The line transports the bleach liquor from storage tanks to a large pine pulp bleaching tower at the International Paper Company's Mobile, Alabama, plant. In the eight years this line has been in service, *there's not been a single failure in the Saran Lined Pipe.*

The plant also relies on Saran Lined Pipe to carry alum to a groundwood mill for pH control, and to carry waste acid salts to spray towers for soda and sulphur recovery. Because of the pipe's extreme resistance to corrosion and chemical activity; and because of its rigidity, which eliminates the need for continuous external support, International's engineers report they are ". . . enthusiastic . . ." about the use of Saran Lined Pipe.

For paper plants and for other chemical processing operations which require piping systems with extreme resistance to corrosion and chemical activity, Saran Lined Pipe is an ideal choice. Saran Lined Pipe, fittings, valves and pumps are available for systems operating from vacuum to 300 psi, from below zero to 200° F. They can easily be cut, fitted and modified without special equipment. For more information, write Saran Lined Pipe Company, 2415 Burdette Avenue, Ferndale, Michigan, Dept. 2286FC9.

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It was predicted that hundreds of chemicals would appear on these lists. In the meantime industry waited. When the lists did appear, extensions were granted *ad infinitum*, and included some chemicals which perhaps should not have been included.

The granting of extensions should not be interpreted by industry as general relief from the problems of obtaining the evidence necessary to establish the safety of the chemicals they use. The extensions expire in March of 1961 and could expire sooner if a public health problem should arise over the use of a chemical. The industry is therefore operating under a day to day existence. Legislative relief is not expected as evidenced by Mr. Flemmings failure to obtain congressional action to ease the problem for industry. Industry has no excuse now to delay working out its problems.

There is a great deal of confusion that still exists. One of the questions that bothers any scientist is that one concerning "how safe is safe." How can you, for example, answer the problems created by the Delaney clause in the amendment which states, "provided that no additive shall be deemed safe if it is found to induce cancer when ingested by man or animal." Science has *not* provided all the answers to the problems of cancer up to this time. What are carcinogens and what are the precursors of cancer? If we must determine the carcinogenic properties of certain chemicals then we must go further and determine the effect of *all* chemicals in cancer formation. To what extent are we justified in forcing industry to assume the burden of such a controversial subject.

Apparently many scientists are confused by test requirements. It would seem that some effort should be made to include the opinions of the technical personnel of industry to assist in clarifying test procedures. For example, some analytical techniques must actually detect nothing. This is a self-defeating thing for industry, since nothing is insoluble; you can always find something. We find that in setting up tests sensitive to a part per billion we may actually defeat ourselves, whereas, the results from a method sensitive to only a part per million may be acceptable.

There are other reasons for the confusion which exists. The delay of FDA in answering mail is one. Everyone should appreciate the burden placed upon our public officials at this time and should anticipate reasonable delays. The problems created by the use of colors is another. When are we going to obtain relief from this particular problem?

What constitutes an impervious barrier and does the inclusion of a barrier in a package give the manufacturer the right to use all or any type of fibrous furnish in the remainder of the package?

Are the tenets of sanitation, upheld by part of the industry over the past dozen years or so, to be endangered by a regulation designed to safeguard public health. It would appear that the answer to this question could be found by a definitive answer to what constitutes "good manufacturing practices." I believe that "good manufacturing practices" can be maintained most advantageously by adherence to a sanitation program within each mill. We realize that the sanitary quality of all food grade packaging materials is not of primary importance in establishing their acceptability under the 1958 Food Additives Amendment. However, we know from past experience that the sanitary practices of processing are reflected by a microbial examination of the finished product. It is almost impossible under good sanitation practices to use chemicals or fibrous furnishes which are questionable without affecting the characteristics of the package or the packaged food.

Not all of the picture is black. There have been two important actions by the FDA in recent weeks which may give relief and may mark a new approach to the food additives clearance procedures.

One is the filing of a petition in the April 8, 1960, Federal Register which would clear the use of 240 components of can liners which might migrate into food.

The petition provides "for the use of certain substances in the formulation of organic coatings for food containers in direct contact with food, providing that the total addition to the food of any extractable therefrom will not exceed certain designated tolerances."

If this petition results in a food additive order, it appears possible that the FDA may consider the same approach by others.

The petition would clear any combination of the can liner components if they are produced under specification and if the extractable total of all components does not exceed 50 p.p.m. The necessity of setting zero or near zero tolerances for a large number of food container components is avoided.

Another milestone is the food additives order on polypropylene for general food packaging use which appeared in the April 16, 1960, Federal Register. Here the quality control measure for the production of polypropylene is spelled out. It is no longer necessary to carry out analytical tests for determining residues of polypropylene in the food. Tests must be carried out only on the polypropylene to insure that it meets prescribed standards of quality.

Those of us in the sciences must be as objective in our approach to the entire problem as possible. We can see the need for the type of legislation which caused such a turmoil in the paper industry. We can also sympathize with the problems that are facing industry in obtaining the answers to its problems. However, we believe it is rather impractical to assume that industry will be put out of business by the new law. On the contrary, we believe industry will be strengthened by the law. The confidence of the public in industry will also be increased.

Many of you have probably read William Longood's book, "The Poisons in Your Food." You undoubtedly were impressed by the facts, the distorted facts, the truths and half truths, as well as the opinions that were expressed in this book. You can perhaps realize the impact this book would have upon the general public and in turn upon our congressmen. The administrators are subjected to these pressures day in and day out.

It certainly would be nice if we could all look at the 1958 Food Additives Amendment like the person who wrote me recently in reply to my request to him for information concerning his product and its status under the 1958 Food Additives Amendment. My letter was the usual letter which mentioned the work we were doing in connection with the Amendment for industry. The reply contained only these words: "We do not have the information you requested since we never realized our product would ever be used to package cranberries."

Presented at the meeting of The Empire State Section of TAPPI, held in Whiteface, N. Y., June 9–11, 1960.

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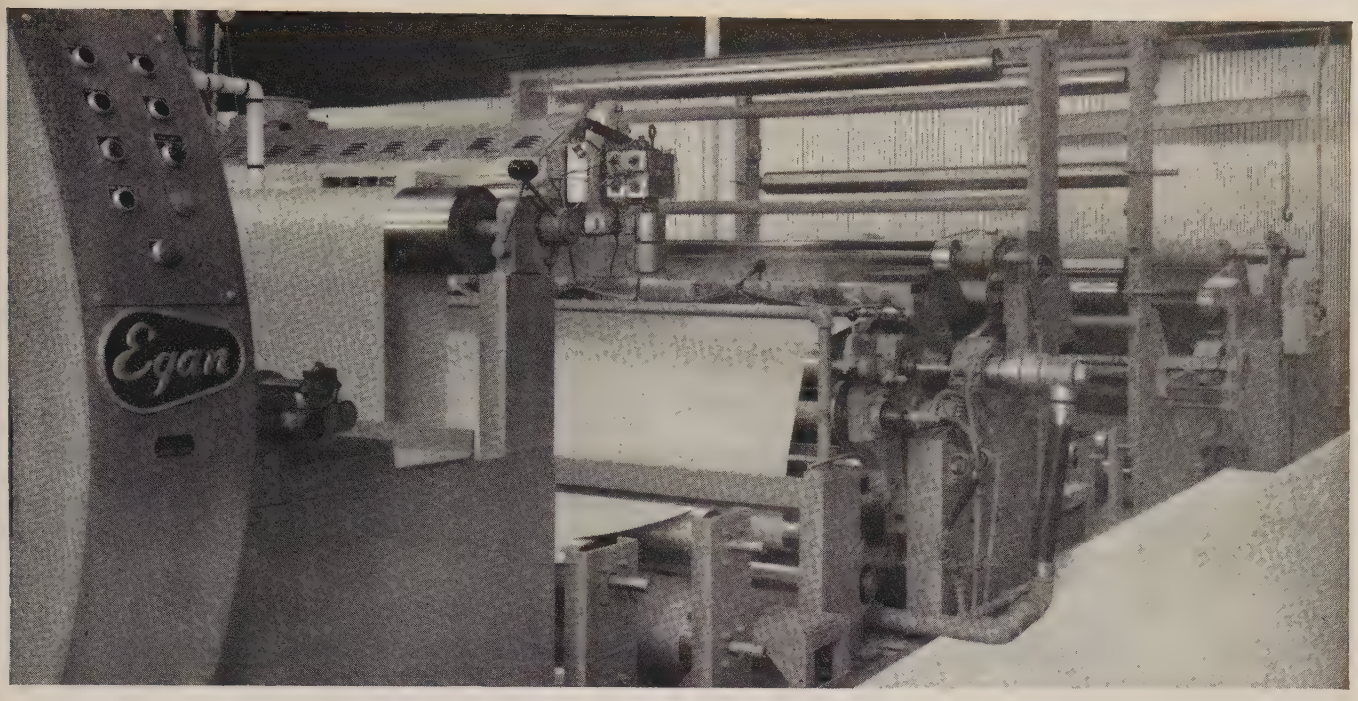

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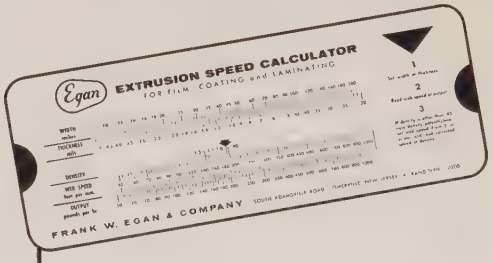

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A Review of the Activities of the APPA-NPA Food Additives Liaison Committee

R. C. CRAIN

In september of 1958, Congress amended the Food, Drug & Cosmetic Act by passing the Food Additives Amendment of 1958. This action followed eight years of congressional activity in which a number of proposed bills were considered and the Miller pesticide amendment was passed. Throughout this period both the American Paper & Pulp Association and National Paperboard Association, as well as other associations and individual companies, followed the progress of these proposals through committees, testifying at hearings in an effort to have any legislation be as practical and workable as possible. Many other groups were active, notably the Manufacturing Chemists Association and the Society of the Plastics Industry.

At the same time problems of adequate protection of the food supply were being considered by the Food Protection Committee of the National Research Council and its industry liaison panel.

During 1958 it was felt that cooperative efforts of these groups and the Food & Drug Administration had resulted in the proposal of reasonably adequate legislation. The inclusion of the Delaney amendment at the last moment complicated the situation by imposing specific limitations on administrative procedures.

From discussions with the Food & Drug Administration following publication of the "Tentative Definitions and Procedural and Interpretive Regulations," Dec. 9, 1958, it seemed obvious that it was going to be necessary to establish whether each and every component of paper and paperboard used in food packaging could be a food additive under the law by reason of transfer to the food under normal conditions of use. When these tentative regulations were made final on March 28, 1959, the list of materials generally recognized as safe was omitted and under the circumstances it was not practical to assume the safety of any component of paper.

From the beginning it seemed rather obvious that it was going to be up to the individual producer of paper and paperboard to determine whether or not his product contained food additives subject to regulation. It seemed equally apparent that an attempt to clear specific grades by demonstrating the absence of transfer or the safety of all possible components, some of which are present in very small quantities, would involve a tremendous amount of work for everyone. Because most components of paper were believed to be reasonably safe, and have been used for many years without known harm, there appeared to be a good chance of clearing most of the essential materials used in paper and board manufacture by presenting a list of these components to the Food & Drug Administration, describing their conditions of use, and obtaining whatever additional data might be necessary. It was obvious that if this could be done by the American Paper & Pulp Association and the National Paperboard Association, which together represent most of the paper manufacturers in the country, a great deal of time and effort could be saved for the individual mills, for the Food & Drug Administration, and for everybody concerned.

The Chemical Additives Committee of the American Paper & Pulp Association and the Biological Committee, now the Biological and Chemical Research Committee, of the National Paperboard Association together with the staff organization and legal counsel of both associations cooperated in formulating a program. The Food Additives Liaison Committee was created as a joint committee to coordinate the activities of these associations and to act for them in contacts with suppliers, the Food & Drug Administration, consulting toxicologists, and other trade associations. This committee with the assistant secretaries of each association formed a small group, actually seven with some alternate assistants, each of whom has spent a considerable amount of time on this problem during the past year, particularly the chairman of this committee.

A comprehensive list of chemicals used in paper and paperboard was obtained from answers to a questionnaire submitted to a group of representative manufacturers. This list was restricted to materials used in normal manufacture, through calendering operations, excluding any materials added in printing or other conversion operations. It was also restricted to materials used by at least four mills. No attempt was made to list certain kinds of materials except by classes, for instance; proprietary materials whose chemical identity was not known, surface active materials and anything such as emulsions containing them, and dyes to which the Food Additives Amendment does not apply. After compiling and editing this list to correct for obvious omissions and to convert to the form in which the material used would probably appear in the finished paper, this list was reviewed with expert toxicologists in the Food & Drug Administration, in the food and chemical industry, and in independent laboratories serving as consultants. From this review it was possible tentatively to classify materials into those generally recognized as safe, those for which prior sanctions existed, those for which there was insufficient information, and those which were too toxic to be further considered, either in fact or by reputation.

Contact was then made with the majority of suppliers of the materials about which there was insufficient information to see how much information they had or could supply, and what approach, if any, they had made or were planning on making to the Food & Drug Administration. Certain suppliers had initiated very excellent and adequate programs to clear specific materials. Others were in the process of setting up programs. Some, however, had made no start and these were encouraged to appropriate action. Except for information on conditions of use the data necessary for requests for clearance or extension were developed by companies supplying the paper industry and they, or their associations, are continuing to carry on this necessary work.

Very considerable clarification and better definition of the problem areas involved resulted from a series of discussions between the Liaison Committee and representatives of the FDA Divisions of Food & Pharmacology. A review of the manufacturing practices of the paper industry and evaluation of the toxicological significance of quantities of chemical components likely to be present, either incidentally or for some purpose, showed quite clearly that no real health hazard then existed in the use of paper and paperboard packaging materials. A very few chemicals, principally mercury slimicides, were considered too hazardous for continued use. These were not being used to any extent in papers in direct contact with food. On a number of materials the Administration wanted more information than was then available, but was of the opinion that for the more important materials this information was already being developed and would result in adequate demonstration of safety. Considerable progress was also made in determining how the possibility of transfer might be estimated in relation to the normal use conditions of the packaging material.

In brief, as a result of efforts along these lines, the two paper trade associations were able on February 4 to submit to the Food & Drug Administration a list of paper and paperboard components classified as to (1) substances generally recognized as safe, (2) substances for which prior sanctions have been granted, (3) substances for which extensions are required in order to complete the studies, and (4) substances whose intended use involves no migration. By this time it was known that detailed requests for extensions had been filed with the

R. C. Crain, Technical Director, Rhinelander Paper Co. Div., St. Regis Paper Co., Rhinelander, Wis.

U.F. Concentrate in Starch-Clay Coatings Boosts Wet Rub Resistance, Printability of Paper

Latest pilot runs show you can improve coatings using urea formaldehyde concentrate to insolubilize a variety of commercial starches

The addition of U.F. Concentrate-85, Nitrogen Division's urea formaldehyde product, to starch-clay colors formulated with a variety of commonly used starches, produces coated paper with improved wet rub resistance and printability. The paper is comparable in quality to paper coated with butadiene-styrene or acrylic latices, and it meets U. S. Department of Agriculture requirements for good packaging.

An added advantage: The preservative action of the contained formaldehyde in U.F. Concentrate-85 retards starch deterioration, sharply reducing unpleasant odors common in hot weather.

These beneficial effects were demonstrated in an extensive series of trial runs on a high-solids pilot plant roll coater operated under plant conditions. The tests were conducted to determine optimum conditions for improved coatings.

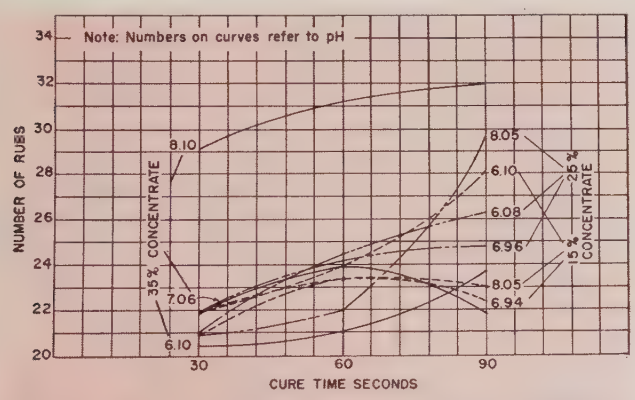

Figure 1 — Effect of cure time on wet rub resistance of starch-clay coatings formulated with Flowkote starch plus varying amounts of U.F. Concentrate-85 and applied at different pH levels.

Variables measured were: pH, curing time, urea formaldehyde concentration and type of starch used.

Starches used were National Starch and Chemical Corporation's Nadex 350, a corn dextrin; Flowkote, an oxidized starch; and Amioca. Adhesive concentration in all cases was 16-18%, based on weight of dry clay.

WET RUB RESISTANCE

Wet rub resistance, determined on American Instrument Co.'s wet rub tester, increases with cure time. How great an increase depends on the starch, the more reactive starch showing the more pronounced effect. Figure 1, on which pH and amount of U.F. Concentrate used in the trials are parameters, shows this relationship for Flowkote.

In all cases, a 25% concentration of U.F. Concentrate-85 (by weight, based on weight of dry starch) gives better results than a 15% addition. However, more than 25% is not generally needed for satisfactory wet rub resistance.

The effect of pH varies, but made no critical difference within the pH range investigated.

PRINTABILITY

Printability, determined by IGT printability tests run on calendered sheets, increases with cure time for a starch such as Flowkote (Figure 2). Figure 2 also shows that for Flowkote, concentration of U.F. Concentrate-85 above 25% decrease printability, and that printability decreases with increasing pH.

With the more reactive Amioca starch, neither cure time nor pH has much effect on printability. However, printability increases with the amount of concentrate added.

ACTION OF U. F. CONCENTRATE

Experimental results show that U.F. Concentrate-85 is composed of methylolureas in equilibrium with free formaldehyde. All the contained formaldehyde is available for further reaction — in this case, to form stable, resinous products involving chemical linkages of the starch and cellulose. These are the same reactions for which coaters use formaldehyde and its methylol derivatives.

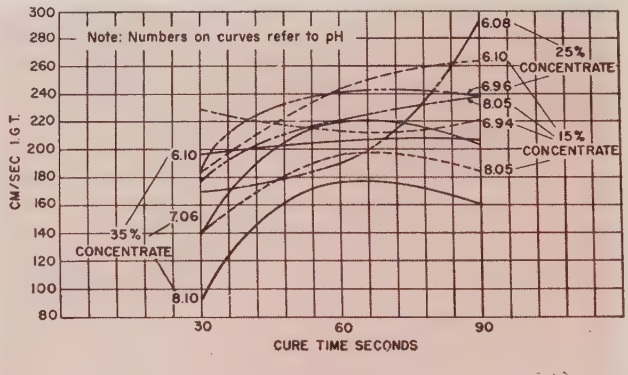

Figure 2 — Effect of cure time on printability of paper coated with starch-clay colors containing Flowkote starch plus varying amounts of U.F. Concentrate-85 and applied at different pH levels.

U.F. Concentrate-85 contains 85% active ingredients — 60% formaldehyde and 25% urea, by weight. You'll find complete information on it in Allied Chemical's 36-page brochure, "U.F. Concentrate-85". Also available is a reprint of an article describing details of its use to improve starch-clay coatings. Write for your copies today. 2819

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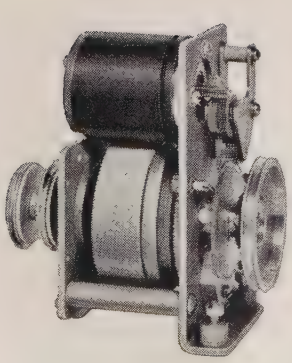
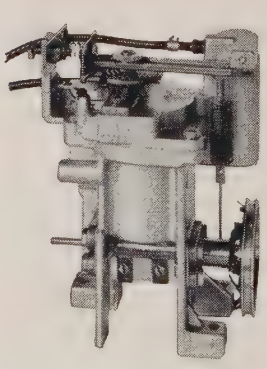


700J (electronic) servo motor is 2 phase, size 15, 60 cycle, 117 volt—built to military specifications. Precision gearing couples the servo to a precise feed-back device with high torque.



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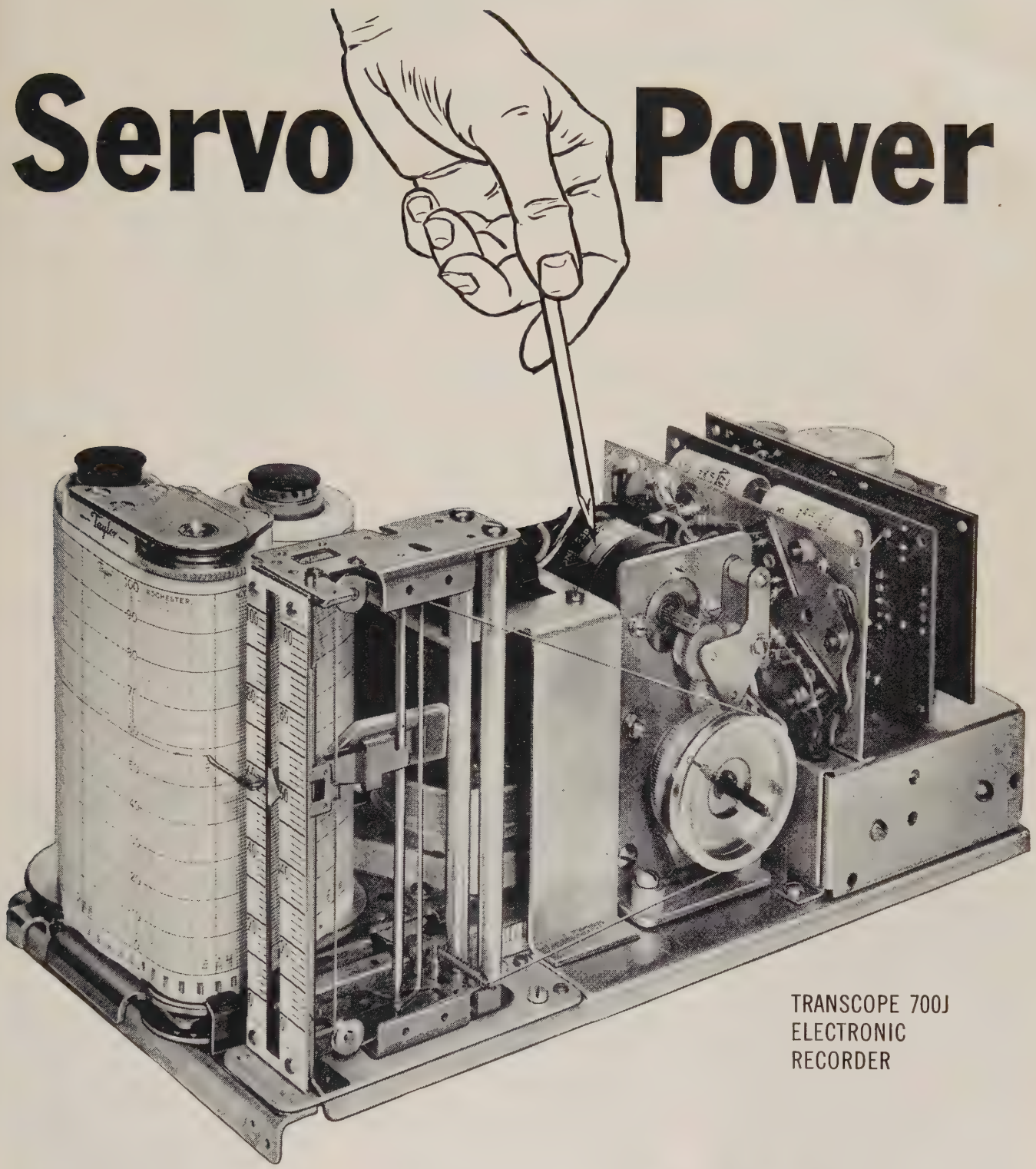

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MEAN ACCURACY FIRST

Food & Drug Administration for all of the materials listed in group 3. On February 24, Commissioner Larrick replied to the request for approval of these lists as submitted, pointing out that some relatively minor changes were found to be necessary. With these changes the lists were published in the Federal Register March 1, 1960, listing those substances not expected to migrate as having prior sanction.

The Food & Drug Administration found it inconsistent with policy to publish in the Federal Register anything regarding the reuse of waste paper, because this could not be described in terms of specific chemical identities; however, approval was given to the major uses of waste paper in normal practice by the Commissioner's letter of February 24.

The information which had been compiled over a period of more than 20 years by the Biological Committee of the National Paperboard Association was of considerable value in the discussions with the Food & Drug Administration. This committee, now the Biological & Chemical Research Committee, is now conducting an investigation designed to establish the absence of significant transfer from paperboard to food under normal conditions of manufacture and use.

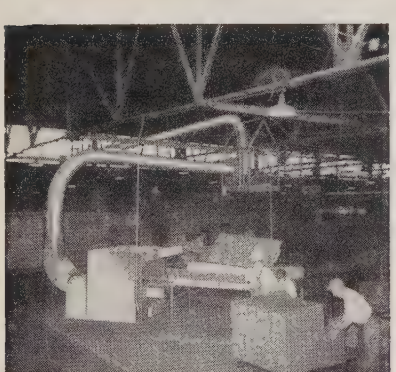
Prior to March 1, 1960, members of the American Paper & Pulp Association and the National Paperboard Association were periodically advised of progress through bulletins issued by the Associations. Since then these bulletins have been continued to advise members of additional extensions granted under the Food Additives Amendment and to supply partial lists of materials by trade names for which either clearances or extensions have been granted.

Reference to the published lists, which appear in the regulations as Sections 121.101 for substances generally recognized as safe, 121.2001 for substances having prior sanction, and 121.87 for substances for which extensions have been granted, should enable individual companies to determine whether any further study is necessary to clear any specific paper they produce for use in food packaging.

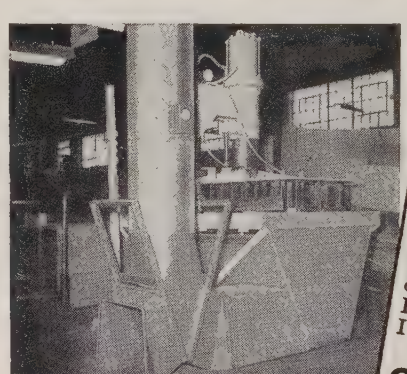
It should be emphasized that each material listed in Section 121.87 of the regulations is permissible only until March 5, 1961, unless additional information is presented to the Food & Drug Administration which permits clearance. The Food Additives Liaison Committee is continuing contact with suppliers so that it may be kept advised of the progress that is being made. In some important areas the work is well along and indications are that clearances will be granted, either by recognition of safety or by the issuance of a regulation describing the conditions under which use is permitted. It is expected that information will be sent out by the associations as it becomes available, and more particularly that the individual suppliers will issue statements to their customers as clearances are received or as it may be necessary to modify existing products in the interest of improved safety. We urge you to keep in touch with this situation in all respects, and to take any action which may be necessary with respect to materials you may use which are not covered by existing regulations and pending applications.

I should like to close by suggesting that you as members of TAPPI consider whether that organization should take an active part in any phase of the problem of food additives. Possibly TAPPI should establish a committee for the purpose of collecting information on methods useful in determining transfer of components of paper packaging materials to food, and of eventually issuing a series of recommended procedures and methods. It appears that there will be need for such methods from time to time as advancing medical knowledge may require further investigation into the possibility that significant transfer might occur.

Presented at the meeting of the Empire State Section of TAPPI, held in Whiteface, N. Y., June 9–11, 1960.



Automatic disposal of large broke sheets accomplished with use of crusher-shredder. Shredded pieces flow easily thru system, and are ready for proper baling or reprocessing.



Automatic trim removal from box stripper also provides a floor level pick up to keep the entire area clear.

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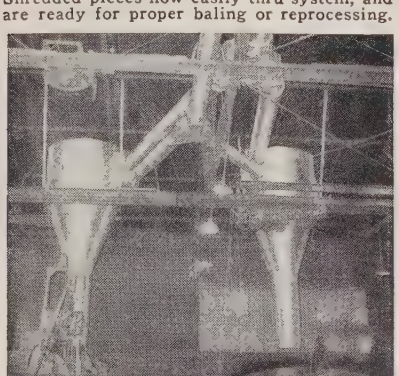
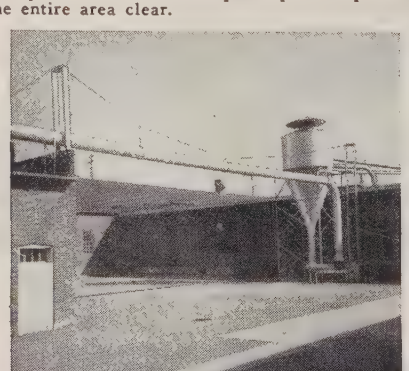
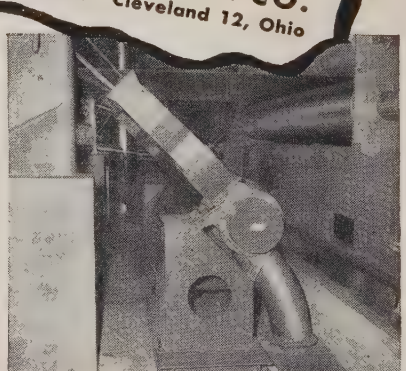


Reprocessing of boxboard trim. Two collectors, and special switching valves permit discharge of trim into *either* of two beaters.



Catenary suspension used to keep yard clear. Pipe runs from transfer collector to separate reprocessing location. Twenty feet of head room allowed for trucks and equipment.



Continuous trim made ready for reprocessing or baling with automatic cutter which is designed as an integral part of the pneumatic system. Cutter accepts continuous lengths of solid fibre to 3/16" thickness, chipboard to 1/4" thickness, widths to 7".

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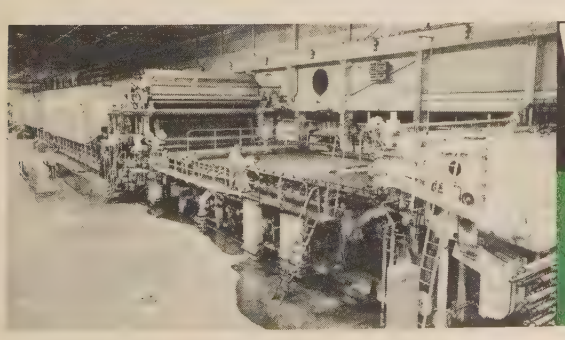
Extensible Unit, No. 3 Machine, Charleston, South Carolina

Vest Virginia Pulp and Paper Company, Kraft Division

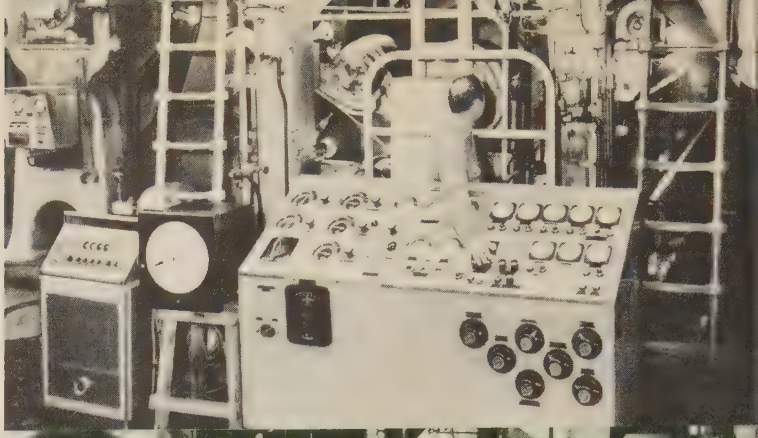


Above is seen the first unit installed for the commercial production of CLUPAK* extensible papers—a process pioneered by West Virginia. Today, 12 of these units are in production, and this new stronger paper is meeting with wide acceptance. Machine at left is one of two at Charleston manufacturing West Virginia's brand-named Kraftsman CLUPAK paper. Please turn page.

*Clupak, Inc.'s trade-mark for extensible paper manufactured under its authority and satisfying its specifications.

Two machines at Charleston manufacture Kraftsman Clupak

The patented CLUPAK process, hailed as one of the important developments in modern papermaking, brings a new "dimension" to paper: controlled stress and strain properties. To date, production has been in the kraft grades, although principles of manufacture and characteristics are applicable to all grades. Clupak, Inc., has appointed Beloit to build extensible units under patents owned by Clupak, Inc. **(a)** Extensible unit, number 2 machine. This is the second production unit installed for the manufacture of CLUPAK papers. **(b)** Drive side number 3 machine. Extensible unit is powered by a Beloit mechanical differential drive. **(c)** Detail of rubber blanket at guide roll position—automatic air guide is at opposite end of the roll. **(d)** Close-up of plaque mounted on extensible unit, number 3 machine.



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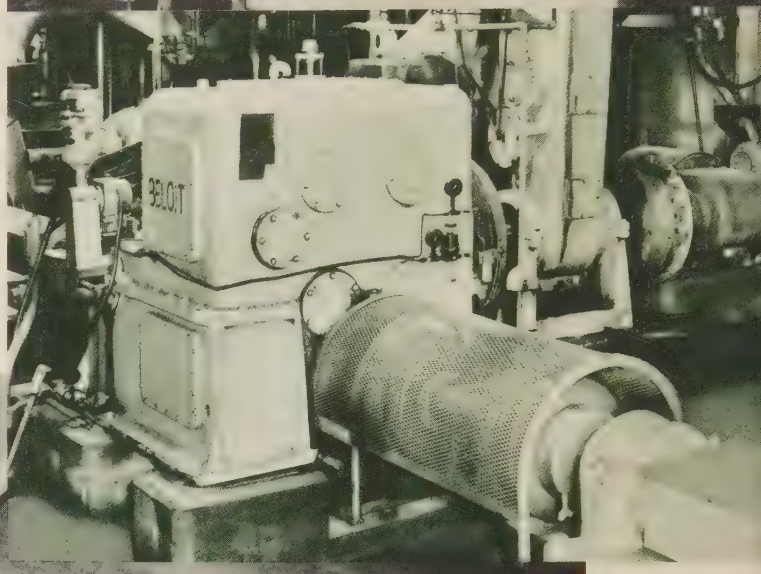

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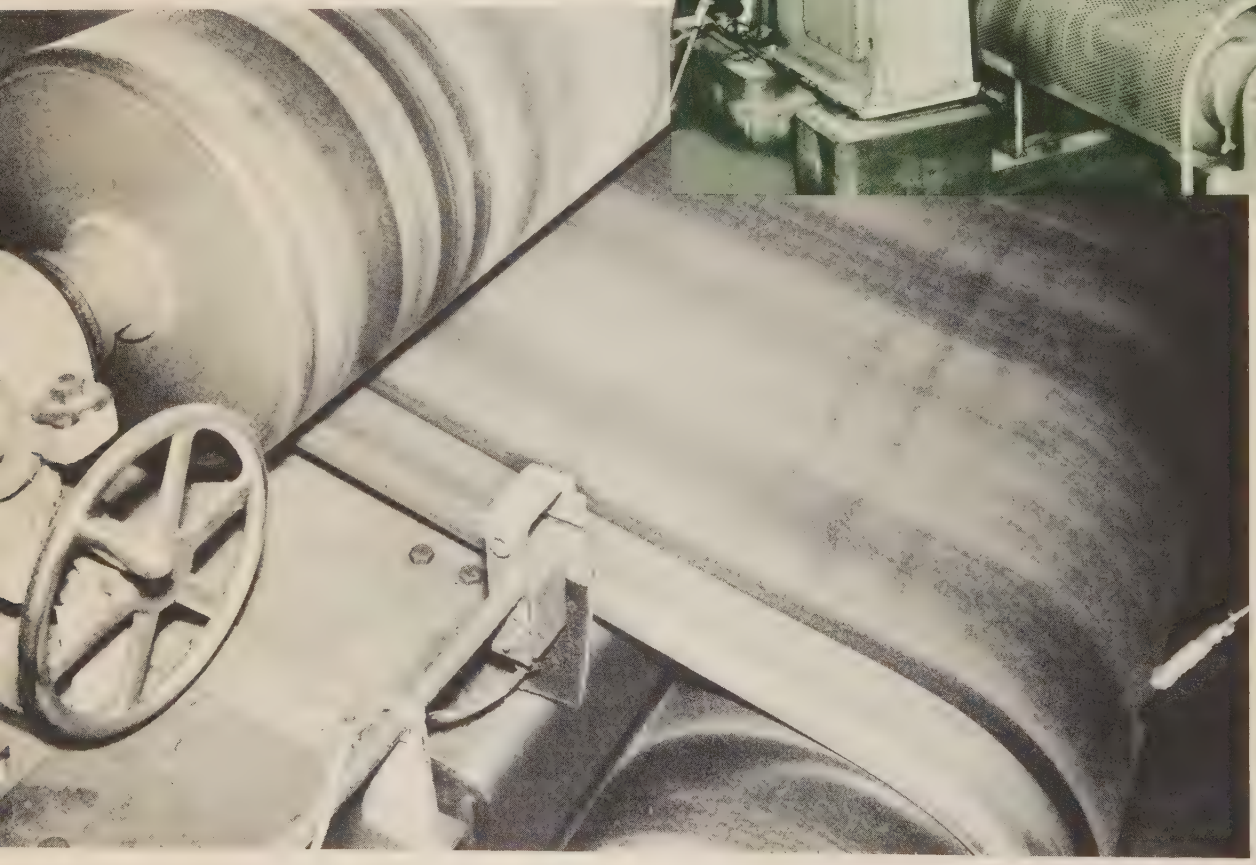

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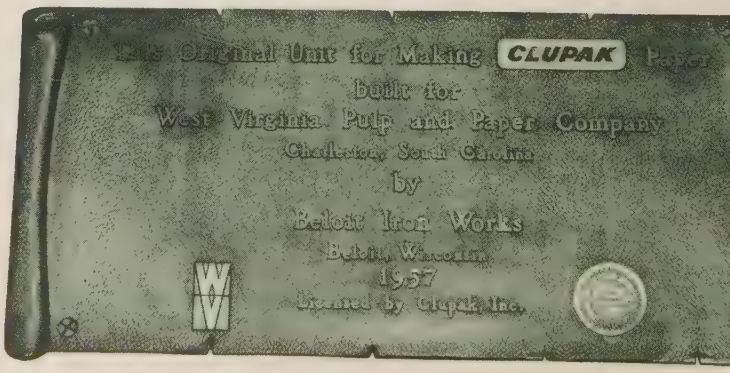


d

BELOIT
PAPER MACHINERY
your partner in papermaking

This insert lithographed on Westvaco's Pinnacle Offset.

CREATED...FOR ECONOMY AND VERSATILITY

WOODBERRY SUPER 887

Asbestos and Synthetic Reinforced Dryer Felt

A highly effective combination of both asbestos and synthetic fiber reinforcement gives WOODBERRY SUPER 887 a higher margin of heat-resistance, a longer and more productive life. Count on this dryer felt for great stamina even when exposed to the most grueling hot spots. SUPER 887 has the potential for running in many positions where full-faced asbestos felts are currently being used. Considerably lower in cost than other asbestos and synthetic combinations and capable of long-term endurance in many of the toughest positions, WOODBERRY SUPER 887 offers the paper maker invaluable economy as well as performance. Chalk up on the credit side the smooth face of SUPER 887 that insures finer finished paper... the versatile character of SUPER 887 that makes it suitable for a wide range of paper-making applications... and conclude with a dryer felt that promises superiority in almost every area... WOODBERRY SUPER 887!

MOUNT VERNON DRYER FELT FAMILY– WOODBERRY SUPER 887 is just one of Mount Vernon's full "family" of scientifically designed dryer felts. There's an individual felt for virtually every paper machine position and every paper-making need.

UNFORMITY Makes The Big Difference

Mount Vernon Mills, inc.

A LEADER IN INDUSTRIAL TEXTILES

DRYER FELT DIVISION

201 East Baltimore Street
Baltimore 2, Maryland
Telephone: SA 7-5845

Another Mount Vernon Dryer Felt Success Story...

One of the leading soda pulp producers consulted Mount Vernon engineers about a dryer felt problem that developed when they initiated a new process at their mills. They discovered that their new peroxide bleach process reduced the life-time of asbestos-and-cotton combination felts in use, to an average span of approximately twenty-five days. WOODBERRY SUPER 887 was recommended. Result: WOODBERRY SUPER 887 stayed on the job, during its first run, for 69 days, yielding an increased dryer felt life in excess of 175%.

MADE ESPECIALLY FOR THE PAPER INDUSTRY

GLIDDEN ZOPAQUE LD-C

Anatase grade TiO_2 combining the best features of both anatase and rutile grades for paper coating

NOW, the better brightness and hiding of anatase TiO_2 is combined with the ease of dispersion and low viscosity features of rutile grades . . . in Glidden ZOPAQUE LD-C.

"LD-C" has smoothness comparable to rutile. It is equally well suited for on and off machine, size press and calender coating. Compatible with all other common paper coating pigments and adhesives.

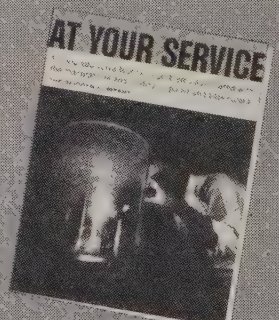
Being an anatase grade, new "LD-C" is for coating of all nonwaxing plain and printed paper and board. And "LD-C" is priced as an anatase. Some users are obtaining savings of up to 2¢ per pound.

Higher machine speeds, heavier coating weights and other advantages are inherent in new "LD-C". To get the full story, or samples, call your Glidden representative or our Baltimore headquarters.

QUALITY Glidden PRODUCTS

THE GLIDDEN COMPANY
Chemicals Division • Pigments & Color Dept.
Baltimore 26, Maryland

MANY GLIDDEN TECHNICAL FACILITIES ARE AT YOUR SERVICE *for development or testing work in paper. Write for this new brochure—just off the press. Ask for "PAPER RESEARCH AND DEVELOPMENT LABORATORIES".*



brings out the best in pigment bindings, coatings and sizings

More and more leading paper makers are finding GELVATOL Resins highly effective for improving their products while gaining the added advantages of economy and easy handling. GELVATOL Resins' balance of properties offers you proved-in-use advantages. Apply GELVATOL from size tub, size press, water box or in coating mixes to produce:

Improved Ink Hold-out. Minimizes ink spread and feathering and produces prints of high gloss. Stretches ink mileage in highly absorbent stocks.

Improved Pigment Binding. GELVATOL Resins produce a bright, opaque sheet with excellent print qualities.

Improved Strength. Increases Mullen, pick resistance and fold endurance.

With capacity recently increased by 100%, GELVATOL polyvinyl alcohol is now available in an even wider variety of grades, and in any desired quantity. Write for full technical information to Shawinigan Resins Corporation, Department 8P, Springfield 1, Massachusetts.

GELVATOL CHARACTERISTICS

Resin Type	Viscosity, cps.	% Residual Polyvinyl Acetate	% Hydrolysis
1-90	55-65	0-2	100-99
3-90	45-55	2-4	99-97.9
20-90	35-45	19.5-24	89-86
1-60	28-32	0-2	100-99
3-60	23-28	2-4	99-97.9
20-60	21-25	19.5-24	89-86
1-30	4-6	0-3	100-98.5
20-30	4-6	19.5-21.5	89-87.7
40-20	2-3	37-42	77-72.9
40-10	1.3-2	37-42	77-72.9

SALES OFFICES: ATLANTA CHICAGO LOS ANGELES NEW YORK CLEVELAND SAN FRANCISCO GREENSBORO ST. LOUIS

GELVATOL® *polyvinyl alcohol by*

SHAWINIGAN RESINS®

AT YOUR SERVICE

Outstanding product and fine service are two major objectives of the Albany Felt Company.

Our good product you know about. Now, meet our customer contact team. Their job is service to you, enabling you to get *more tons per day . . . more days per felt.*

There are executives, sales correspondents, sales engineers and service engineers.

Some call on you directly . . . others write . . . or phone . . . all are dedicated to one principle . . . to be AT YOUR SERVICE.

How many do you recognize?

SALES EXECUTIVES

1. CHAGG CHAGNON
   Vice President – Sales
2. WAYNE DAVIS
   Vice President – Felt Sales
3. JIM SMITH
   Sales Manager

SALES-SERVICE

4. BILL LARKIN
5. TOM TIETZ
6. JOHN WIEGNER
7. RAY PARKER
8. JOE ARMSTRONG

SALES DISTRICT MANAGERS

9. BILL SCHAFFNER
10. CLIFF VAN BUREN
11. JOE TANNER

SALES ENGINEERS

12. LOWELL BROWN
13. CHARLIE PAGE
14. BOB SPELLMAN
15. TOM BURKE
16. LARRY LANE
17. EDMUND PACA
18. RAY DUSTRUDE
19. ED DEWAN
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21. WALT WILLETTS
22. FRANK McGRATH
23. DICK DANDO
24. BRUCE OWRE
25. ED LYON
26. LARRY WOODSIDE
    Chief Engineer,
    Technical Field Service

SERVICE ENGINEERS

27. GEORGE MARSANKIS
28. BILL SHIRES
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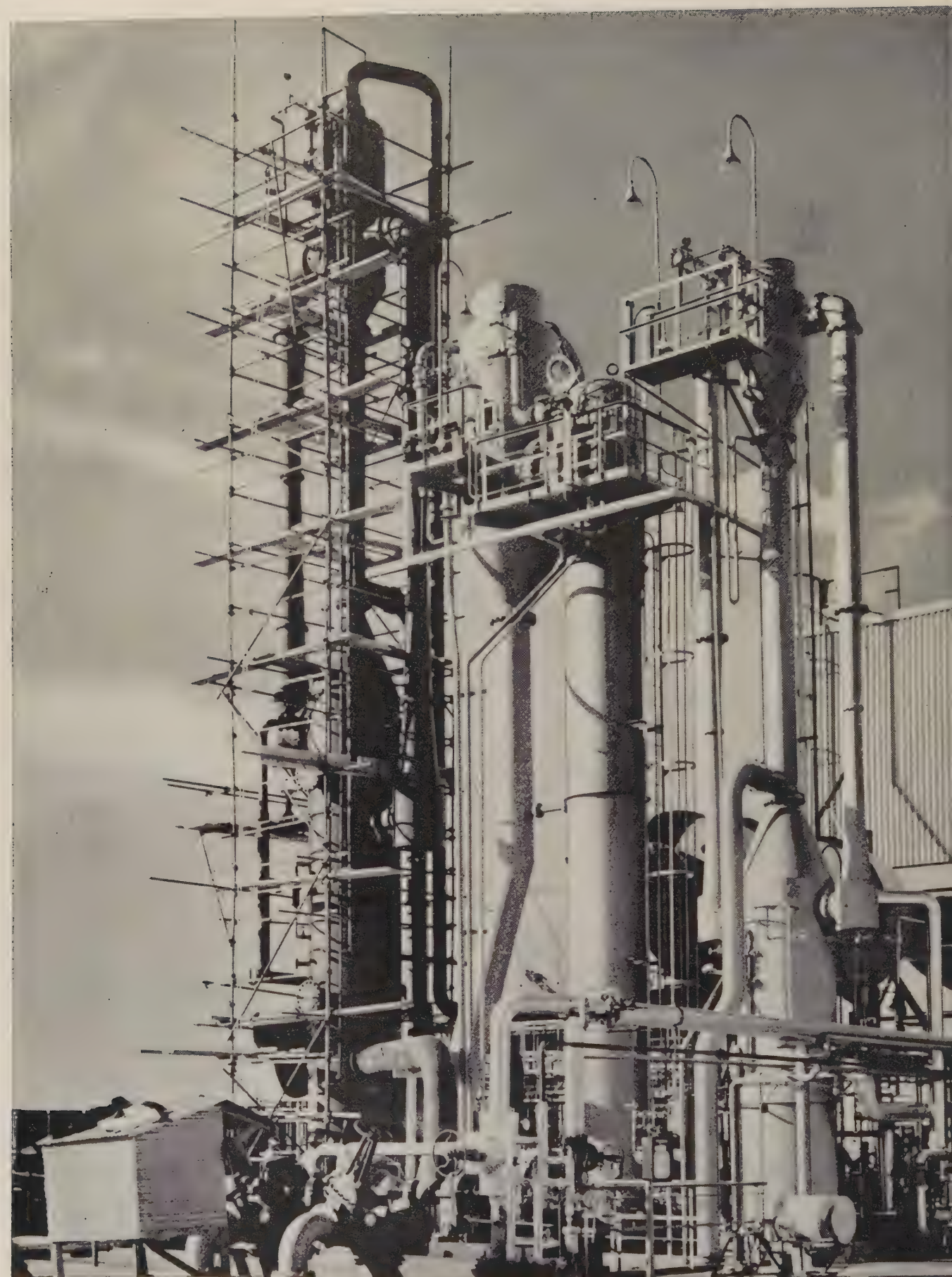
AF

ALBANY FELT
COMPANY
ALBANY, N. Y.

The World's Largest Manufacturer of Paper Machine Felts



PETROTHENE® RESINS FOR FILM AND COATING. Capacity of this U.S.I. plant at Houston, Tex., is being expanded to 200 million pounds of polyethylene per year. U.S.I. also produces 100 million pounds of polyethylene per year at its Tuscola, Ill., plant complex.

U.S.I.'s MANY PLANTS PROVIDE AMPLE SUPPLIES OF PAPER CHEMICALS

for pulping
for converting
for packaging

From chlorine and caustic for bleaching pulp—to polyethylene resins for coating paper and board—U.S.I. is a dependable source of chemical products for the paper industry.

With two chlorine and caustic plants at Huntsville, Alabama—conveniently located in relation to a large number of pulp and paper mills—U.S.I. can offer rapid delivery and prompt technical assistance on these products. Liquid chlorine is available in tankcars. Commercial grade 50% caustic soda is shipped in tankcars, tank trucks, barges.

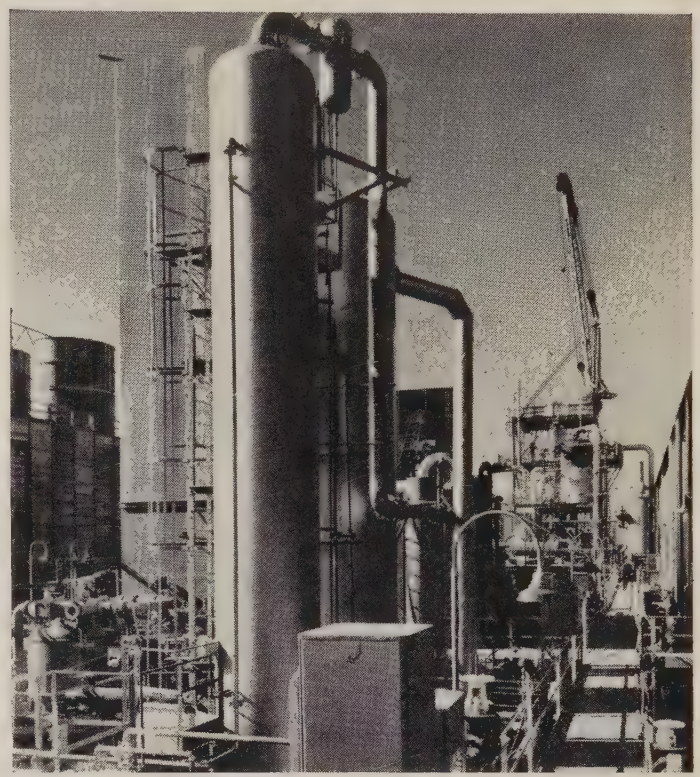
Two other important paper chemicals—sodium peroxide and ammonia—are also available from U.S.I. Sodium peroxide is produced at Ashtabula, Ohio; ammonia at Tuscola, Illinois.

With U.S.I.'s latest polyethylene resin plant expansion at Houston, Texas—and facilities at Tuscola, Illinois—the company's total polyethylene capacity will soon reach 300 million pounds per year. This will make U.S.I. the world's second largest producer.

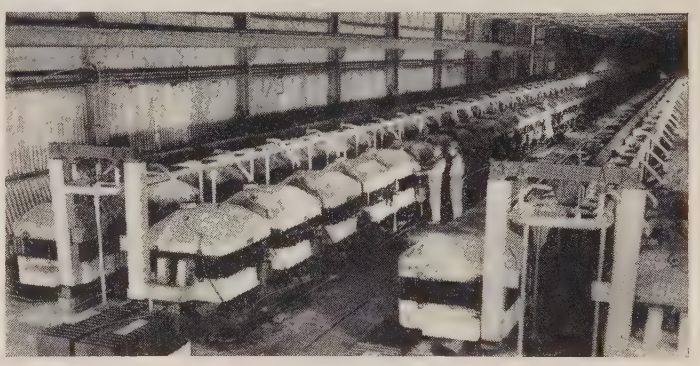
As part of the company's program to assist polyethylene customers, U.S.I. has come up with significant developments in resins for the paper industry. For example, PETROTHENE® 205-15—one of four new U.S.I. resins for paper coating—exhibits greater greaseproofness at any given coating weight than other resins of similar melt index and density. All four resins are tailored for high adhesion, and reduced neck-in, smoking and polymer build-up at the die.

U.S.I. has also pioneered the new technique for producing crystal-clear cast polyethylene film, and has just released new resins for this purpose. More and more converters are packaging with polyethylene now that the clarity problem has been solved, because of the enhanced shelf life which this film gives to paper products.

U.S.I. has a pulp-to-package interest in the paper industry's growth. To take advantage of our research and development work, large capacity, prompt technical service, write or call your nearest U.S.I. sales office, or company headquarters in New York.



AMMONIA is made at this U.S.I. plant at Tuscola, Ill. Polyethylene resins are also produced at Tuscola by U.S.I.



CHLORINE & CAUSTIC SODA. One of the two U.S.I. plants at Huntsville, Ala., producing these basic chemicals for the pulp and paper industry.

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corp.
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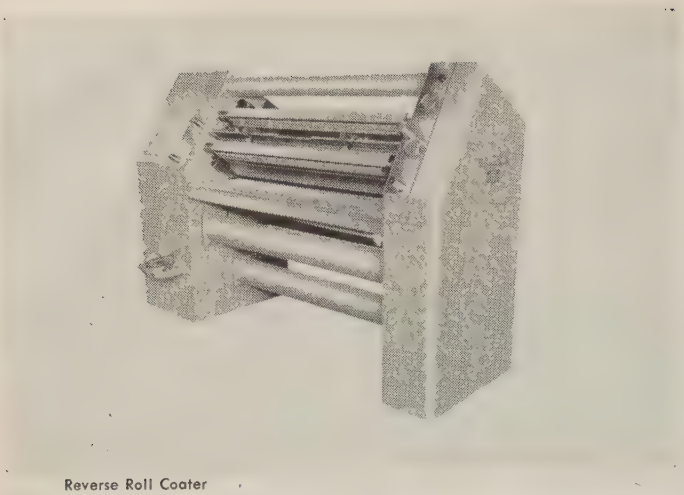
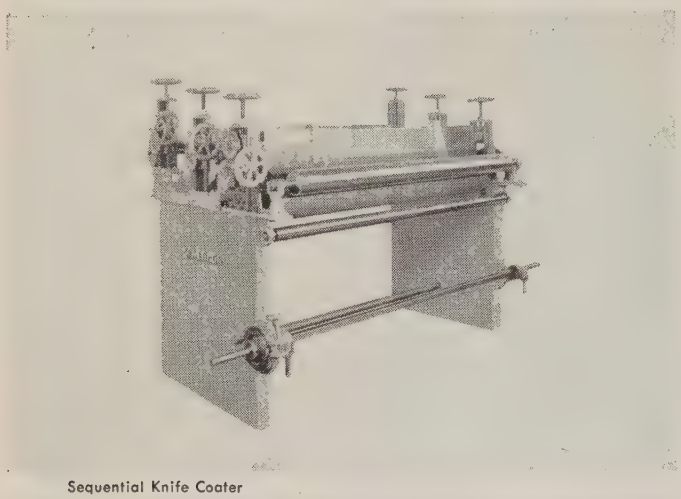
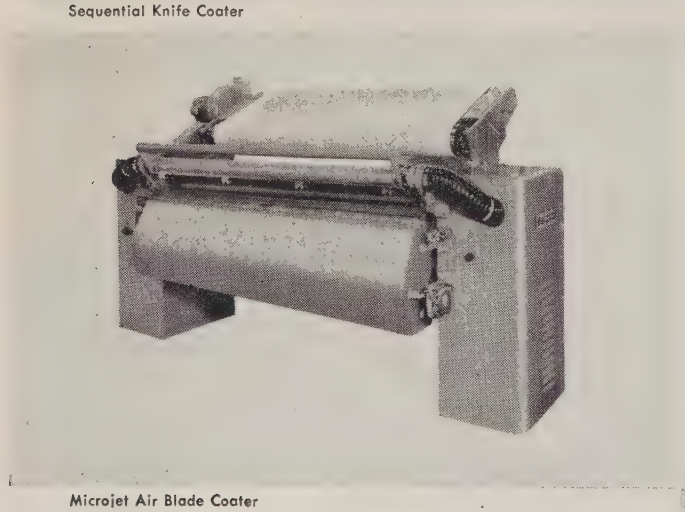
CHLORINE • CAUSTIC SODA • SODIUM PEROXIDE • AMMONIA • PETROTHENE® POLYETHYLENE RESINS



Reverse Roll Coater



Sequential Knife Coater



Microjet Air Blade Coater

WALDRON ADVANCE DESIGN *standard* COATERS SOLVE MANY *special* COATING PROBLEMS

As manufacturers of coating machines for the web processing industry for over a century, Waldron engineers have been called upon to solve innumerable coating problems. The Waldron "standard" line of advanced design coating like those illustrated reflects this vast experience.

These coaters are applied to solve most coating problems. These standard units can be *customized* to meet your "special" requirements.

Complete coating lines including web handling equipment with our Ross Division convection dryers are engineered by Waldron as a single responsible source of supply.

Our engineers are ready to work with you to select the equipment, and our extensive pilot plant facilities are at your disposal for tests.

Write us describing your coating needs. We will be happy to advise how a "standard" Waldron coater can solve your "special" coating problems.

WALDRON
PROCESS MACHINERY

WALDRON-HARTIG DIVISION
Midland-Ross Corporation
Box 791 New Brunswick, N. J.

"Technical competence in web process machinery"

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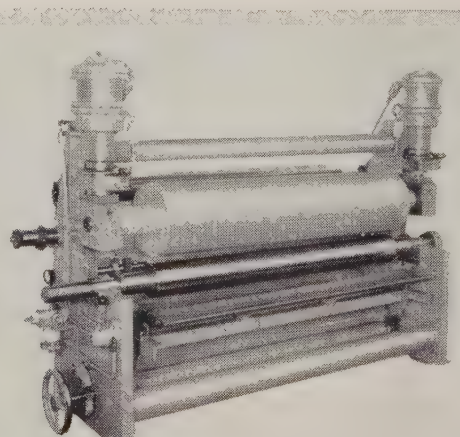

Single Color Gravure Printer

WM-360

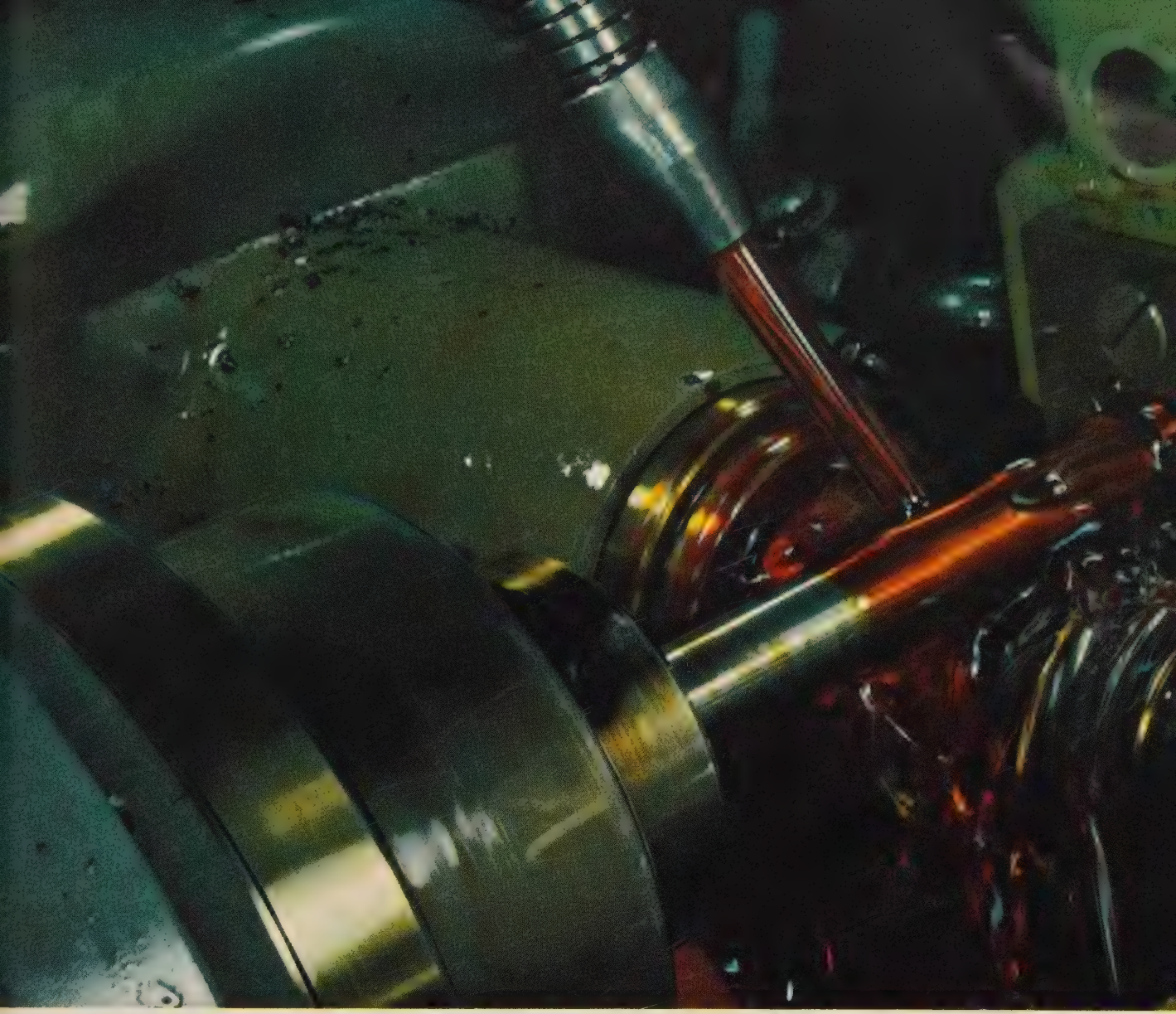

Photo Courtesy of Gulf Oil Corporation

Gleaming Offset...on RHOPLEX-coated stock

This page was prepared for quality offset printing with a coating using a RHOPLEX 100%-acrylic emulsion binder. As a result, the surface is uniformly smooth. Halftone dots reproduce sharply, and colors print with superlative brilliance and fidelity.

RHOPLEX emulsions are excellent binders for coating not only paper, but paperboard as well. In fact, the excellent results produced by RHOPLEX coatings on both bleached and unbleached kraft board have been a boon to package design. The superb printing qualities conferred by RHOPLEX emulsions spark up colored printing on cartons for cigarets, beverages, frozen foods, and cosmetics. In coating paperboard, the low viscosity of RHOPLEX coatings permits coating application at exceptionally high solids, for maximum whiteness and hiding power. Other advantages include excellent flexibility of the dried coating, outstanding water resistance, calenderability at lower-than-average pressures, and very good adhesion. Write for our 16-page booklet "RHOPLEX Acrylic Emulsions in Paper Coatings" for formulating information and technical data on RHOPLEX B-15 and RHOPLEX B-60A coatings for printing papers and paperboard.

RHOPLEX *is a trademark, Reg. U.S. Pat. Off. and in principal foreign countries.*

Chemicals for Industry

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

RHOPLEX

*Submitted by Edward J. Boarini, The Celotex Corporation, 120 So. LaSalle St., Chicago 3, Ill.

Photo by Harold M. Lambert, Philadelphia, Pa.

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"Reminds me of HAMILTON Felts . . . they open new avenues for profits, too!"

"Like the St. Lawrence Seaway,
Hamilton Felts are ultra efficient
in engineered water removal.
They do not shed water
but run it like a sieve.
Hamilton Felts are also pre-shrunk,
'broken-in,' for the machine
on which you intend to use them.
This too—gives you operational savings.
Results for you: less downtime,
more tonnage, more profits."

If one of our present 300 proven styles won't solve your specific problem, we will be happy to design a Hamilton Felt that will. Just ask your Hamilton Felt Service Salesman.

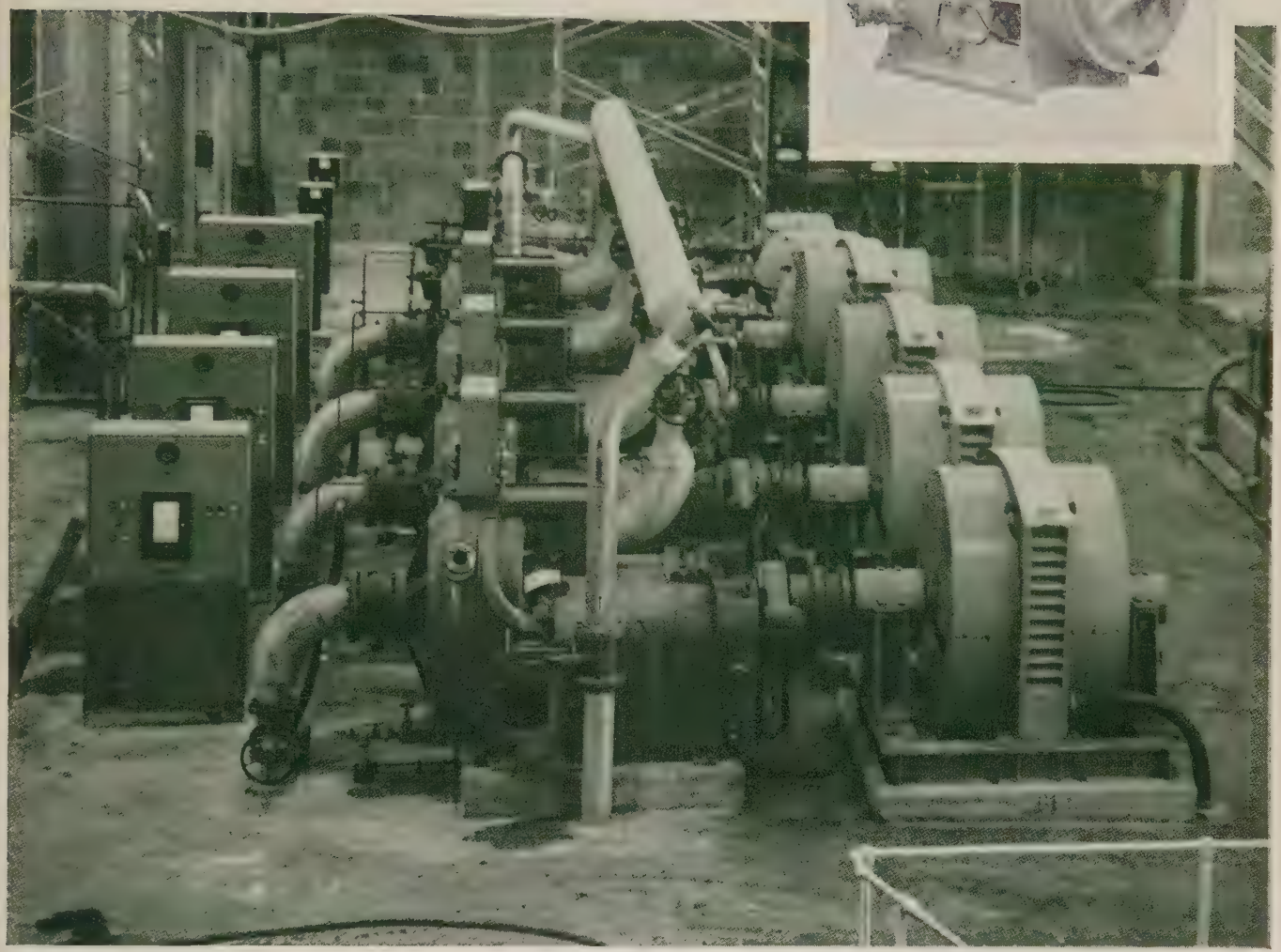
*WIN . . . *A NEW Shakespeare Spincast Fishing Outfit!*

YOU CAN'T BEAT
Hamilton
FELTS

"What famous place reminds you of Hamilton Felts? Tell us why in a few words; sign your name and address and name of company. Each month, the idea from a papermaker that we use wins a new 1960 model Shakespeare Spincast Rod and Reel—FREE! When identical winning ideas are submitted by 2 or more papermakers, the one with the earliest postmark will be considered the winner. *Every U.S. papermaker entrant* receives a famous Rex Spoon fishing lure—FREE. Send me your suggestion—today. Ham Feltz, 612 First National Bank Bldg., Cincinnati 2, Ohio."

SHULER & BENNINGHOFEN, HAMILTON, OHIO

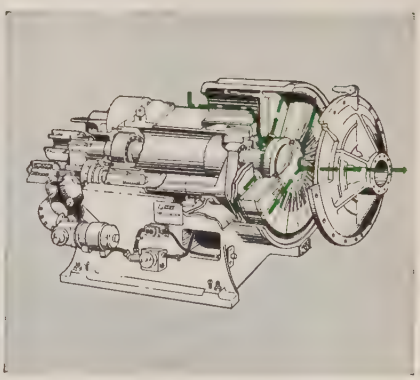
Only 4.4 HP days per ton
Used by Jones Double-D's



. . . at International's Pine Bluff Mill

Production schedules at International's Pine Bluff Mill call for over 500 tons of quality foodboard stock per day — from one 300″ Beloit machine. Helping to make this tonnage possible is an efficient battery of four Jones Double-D's operating in parallel for primary refining. Each unit is driven by a 600 HP motor. Working continuously since the mill was put in operation, *each Double-D has been processing approximately 140 tons per day . . . for an outstanding performance rating of only 4.4 HP days per ton* to accomplish almost two thirds of the total primary refining. Important, too, is the fact that Jones Double-D's save on floor space — since each does the work of two ordinary single disc machines.

The experience at International is typical of Jones Double-D's efficiency in many mills. Why not get high production at low HP days per ton — with less floor space in your mills, too? For full details write to E. D. Jones Corporation, Pittsfield, Massachusetts, for Bulletin EDJ-1083.



With Jones Double-D's, stock under pressure passes between two single-faced stationary discs and one (center) double-faced rotating disc. This results in precision controlled two stage refining.

E. D. JONES CORP. member BELOIT group PITTSFIELD, MASS.

Jones

PULP MILL EQUIPMENT AND
STOCK PREPARATION MACHINERY

Canadian Associates:
The Alexander Fleck Ltd.
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Whiteness to burn...thanks to TITANOX®

It's easier to *throw* dirt out than it is to *wash* it out. And it's easier to maintain the right whiteness, brightness and opacity of lightweight disposable paper products—towels, facial tissues, napkins and many others—if you use the *right* kind of TITANOX white titanium dioxide pigment.

TITANOX-A-WD, anatase TiO_2, is generally preferred for beater pigmented papers especially where the pigment is first slurried with water. The easy dispersion and low water absorption of this pigment make for easy handling and production efficiency. And—in addition to lasting whiteness and brightness—TITANOX-A-WD provides high opacity at low pigment loadings.

However, TITANOX-RA-50, the truly multi-purpose rutile TiO_2, or TITANOX-A, anatase TiO_2, may be better suited to your particular operation. One sure way to find out is to get in touch with our Technical Service Department. They'll be glad to discuss the type of TITANOX that will give you the best value for your pigmentation dollar. Titanium Pigment Corp., 111 Broadway, New York 6, N. Y.; offices and warehouses in principal cities. In Canada: Canadian Titanium Pigments, Ltd., Montreal.

TITANIUM PIGMENT CORPORATION
SUBSIDIARY OF NATIONAL LEAD COMPANY

TITANOX

7887

ACTION!

WHEN YOU CALL ON NALCO FOR ANTIFOAM SERVICE . . .

First, Nalco has the Antifoam Chemicals to meet pulp and paper mill foaming problems effectively . . . and *second,* when you call your Nalco Field Service Man for service you get *real action!*

Your Nalco Representative has test equipment, chemicals and portable feeding equipment . . . ready to go to work, quickly, to solve your foaming problems. With Nalco antifoams on the job, you will get outstanding air release, better washing of stock and substantial reduction in pitch deposits. And Nalco antifoams will result in better formation and better drainage on the paper machine.

When you want antifoam ACTION, call Nalco.

National Aluminate Corporation is now

NALCO CHEMICAL COMPANY

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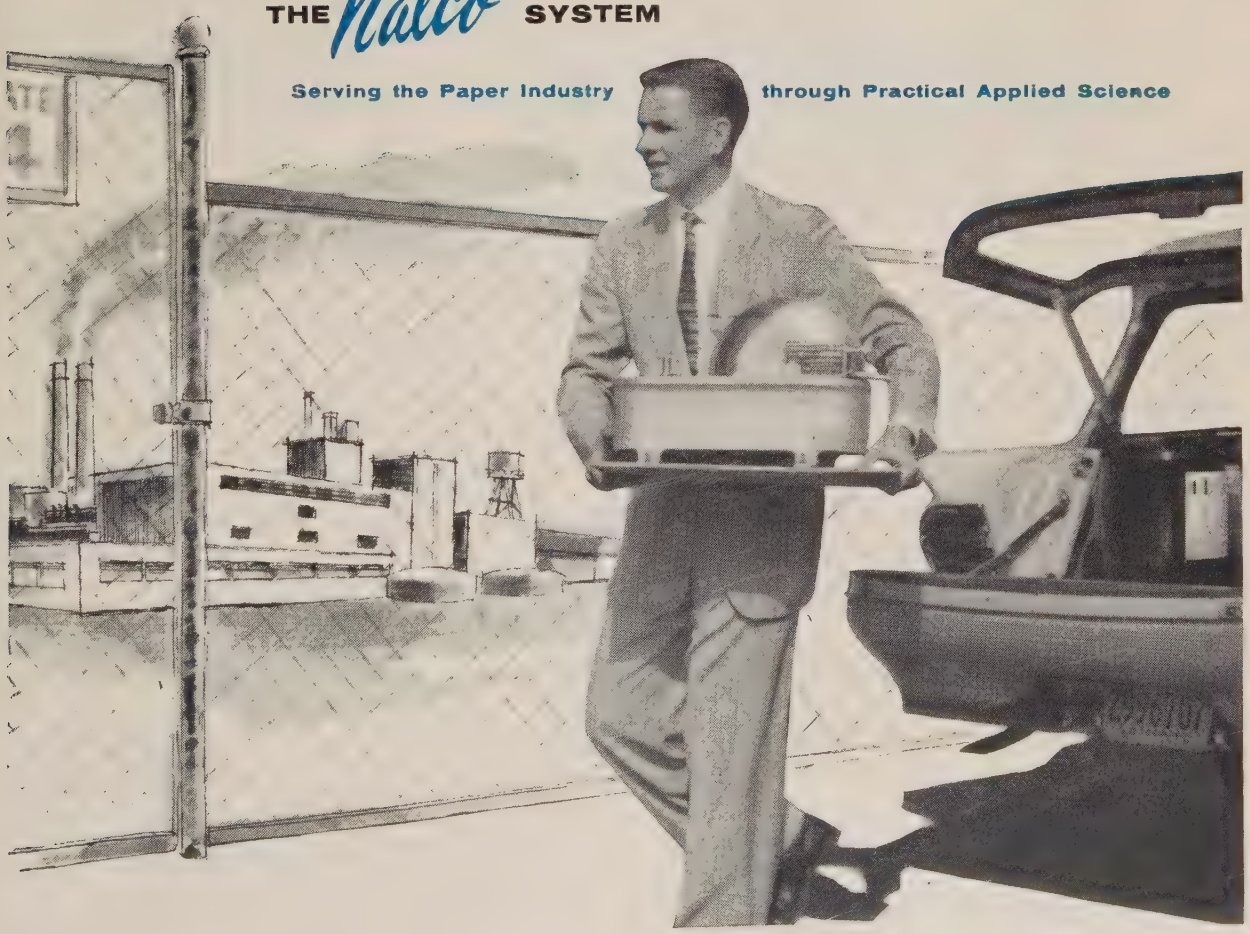
THE *Nalco*® SYSTEM

Serving the Paper Industry through Practical Applied Science



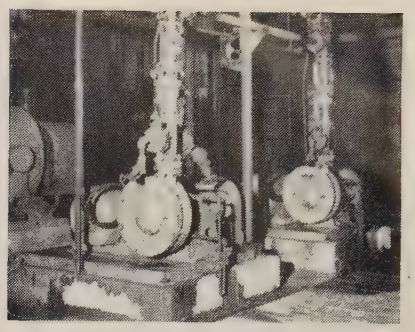
Nalco CHEMICALS

leading manufacturer of wires for

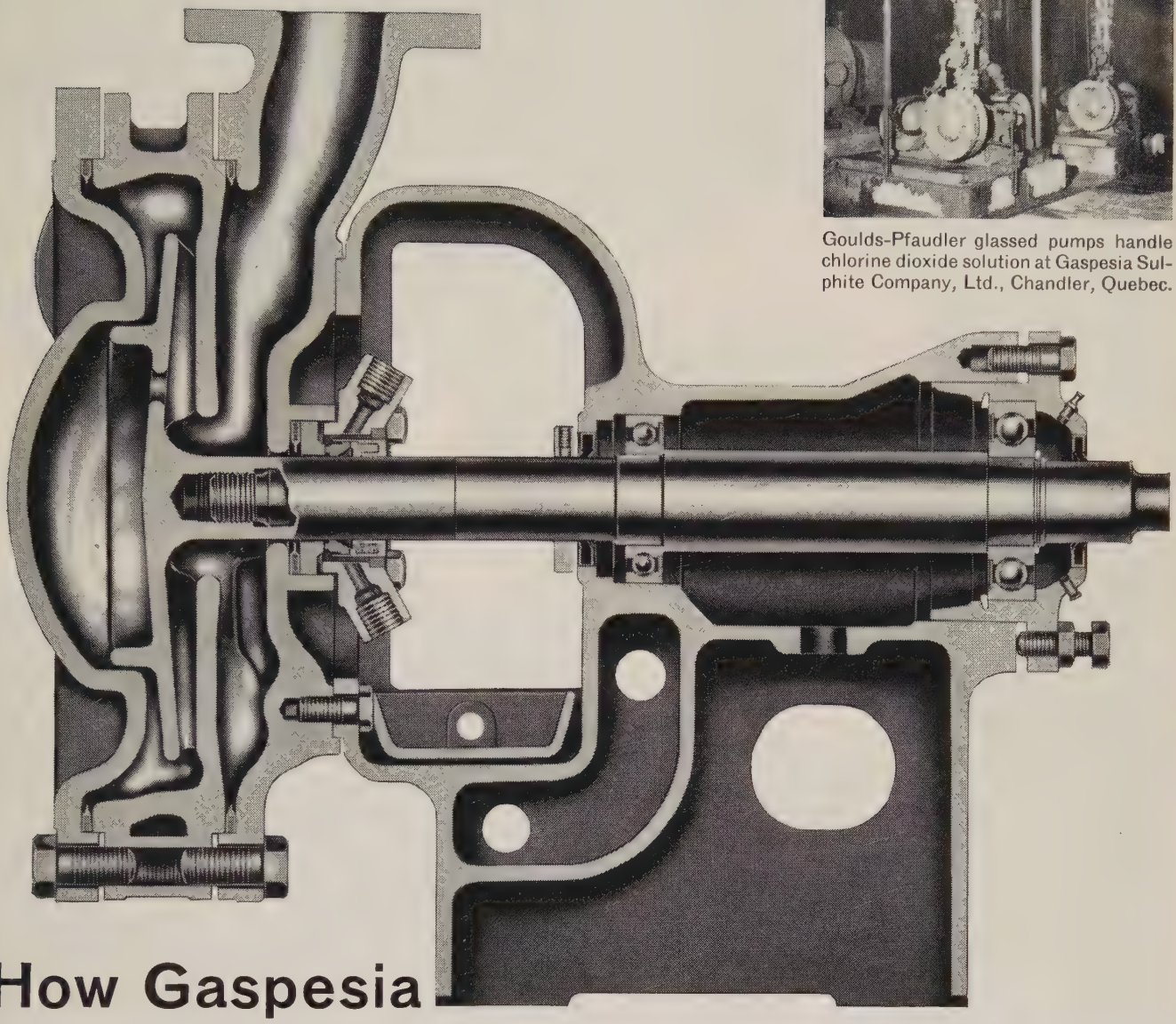
CIGARETTE PAPERS

APPLETON WIRES
are good wires!

APPLETON WIRE WORKS Corp. PLANTS AT APPLETON, WIS., AND MONTGOMERY, ALA.: INTERNATIONAL WIRE WORKS, MENASHA, WIS. AN AFFILIATED COMPANY



Goulds-Pfaudler glassed pumps handle chlorine dioxide solution at Gaspesia Sulphite Company, Ltd., Chandler, Quebec.



How Gaspesia keeps ClO_2 from gobbling up its pumps

The greedy bite of chlorine dioxide loses its nip at the new generating plant and bleaching additions of Gaspesia Sulphite Company, Ltd.

Reasons? A big one is the glassed innards of the two Goulds-Pfaudler pumps delivering chlorine dioxide solution from storage to the upflow bleaching tower. Ten other mills also use glassed pumps to transfer the highly corrosive spent acid effluent solution from the chlorine dioxide generator.

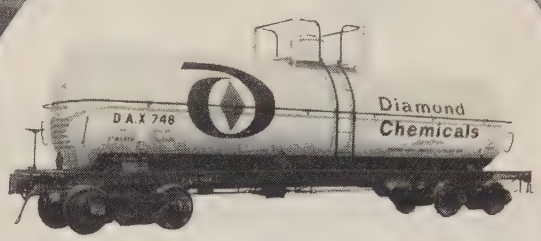
All pump parts that touch this corrosive solution are of glass fused to metal. They resist corrosive attack just as laboratory glassware does. And because the glass is interlocked—not merely lined—to metal, it is tough and durable. Only severe mechanical impact can damage it.

If you measure pump life only in months, Goulds-Pfaudler Glassed Pumps can solve your problem. They resist all acids except hydrofluoric up to 350°F and alkalies at moderate temperatures. They cost less than you might think; less, for example, than some special-alloy pumps.

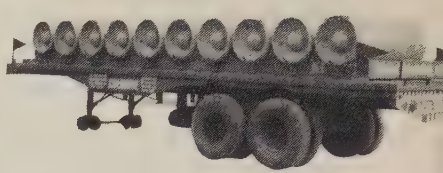
Four sizes offer capacities to 700 gpm, heads to 140 ft.

For specifications, performance curves, resistivity and other useful information, send for Bulletin 725.2. Dept. TA-90, Seneca Falls, N. Y.

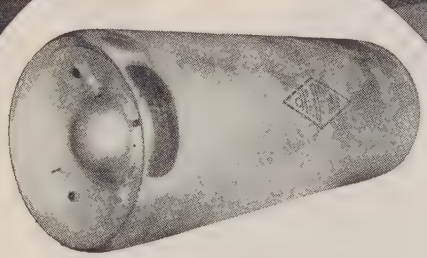
GOULDS PUMPS



Single-unit tank car
16-, 30- or 55-ton capacity. Cars are lap-welded steel construction. Only opening is in dome which contains all valves.



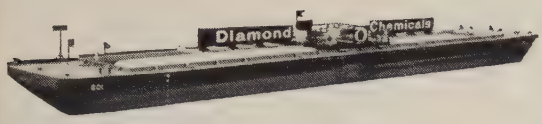
Multi-unit truck trailers
Lots of 6, 8 or 10 containers securely clamped in place on specially designed truck-trailer.



One-ton containers
Steel construction with approved valves. Completely inspected, revalved and repainted for each trip.

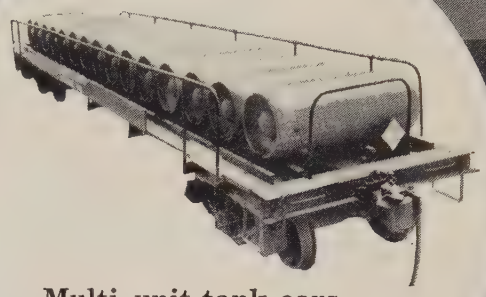
how will you have your liquid chlorine ?

Your source of Liquid Chlorine is the most important thing about it!



600-ton barges

Originating at Muscle Shoals, Ala. and Houston, Texas. The most modern, most economical shipping on inland waterways.



Multi-unit tank cars

Transports 15-ton containers, securely clamped in position. Freight paid only on the chlorine—a big saving.

100- or 150-lb. cylinders

Seamless steel construction, fitted with I.C.C. approved valves. Each is inspected, re-valved and repainted for each trip.

From Diamond, you get Liquid Chlorine where you want it . . . when you want it . . . in the quantities you want . . . at the lowest shipping cost . . . safeguarded by the most highly skilled technical service. You'll always be glad you're doing business with Diamond, one of America's largest producers. For the Diamond "Chlorine Handbook", write Diamond Alkali Company, 300 Union Commerce Building, Cleveland 14, Ohio.

Diamond Chemicals

Bigger Sales...

- No decrease in tensile strength
- Increased cross-directional tensile strength
- No effect on colors
- Rewetting properties are unaffected

Better Production...

- Machine speeds maintained or increased
- Smoother running machines — less down time
- Will not yellow or develop odors on ageing
- Will not foam or froth in use

CELLOLUBE® Q-2

Quaternary Ammonium Paper Softener

Cellolube Q-2 softens napkins, tissue and towel stocks *without adverse effect on physical properties* — puts added "soft sell" in the finished product . . . without creating processing problems. And Cellolube Q-2 gives you wider latitude in pulp selection too! Sheets leave the doctor blade more uniformly, with a finer crepe. And machines actually run more smoothly with less down time. For a revelation in superior paper softening test Cellolube Q-2 now!

Economical Cellolube Q-2 treats tissue stock for as little as $1.33 per ton, and toweling for $3.30 per ton. Increased processing speeds may actually lower your over-all costs! Tanatex is prepared to demonstrate Cellolube Q-2 in your mill on a full scale trial. For details write, wire, phone:

TANATEX CHEMICAL CORPORATION

Belleville Turnpike, Kearny, New Jersey
WYman 8-0732

CHEMICALS
FOR DIFFICULT PROCESSING

How much a year can the Foxboro Stock Blending System save your company . . .

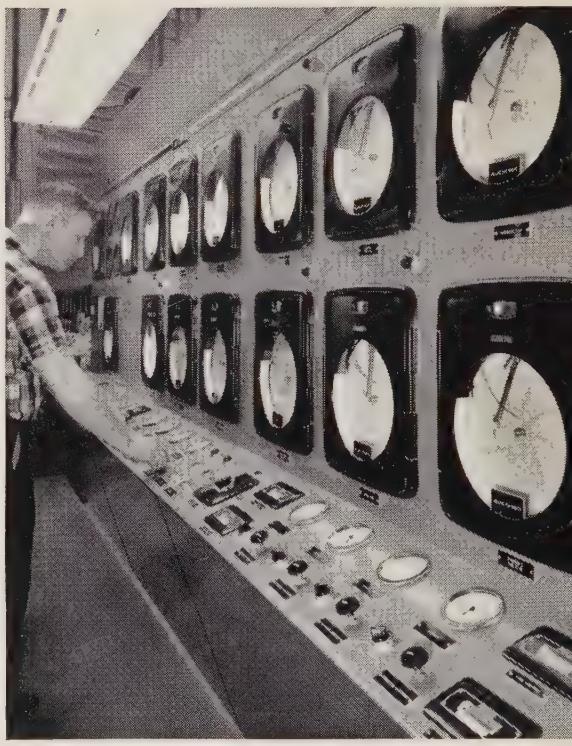
by increasing percentage of first quality paper? ..... $____

by reducing overall waste? ..... $____

by eliminating batch beaters? ..... $____

by reducing down time between runs? ..... $____

by increasing total production? ..... $____

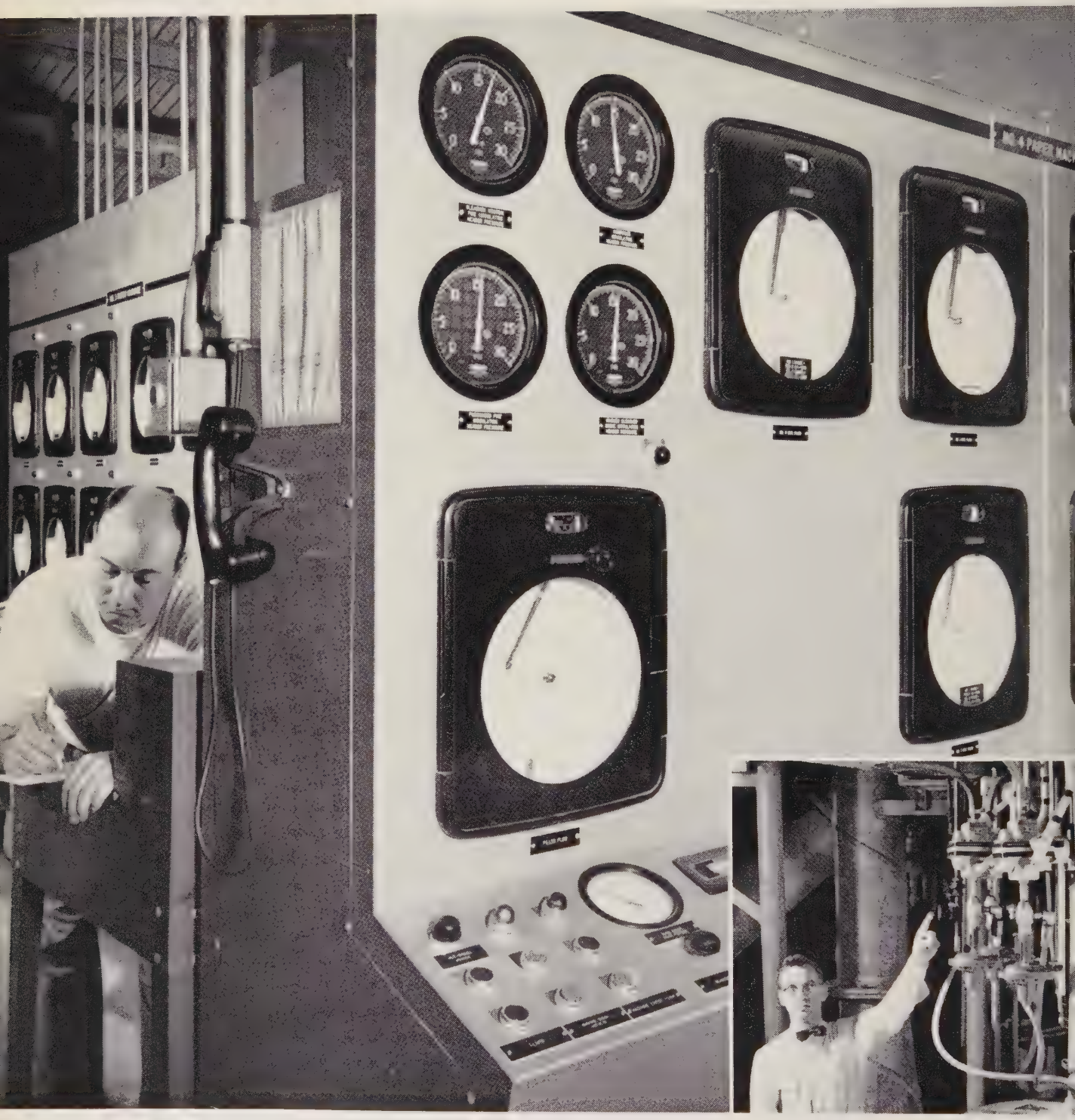


to help you answer this question take a quick look at the experience of one great papermaker . . .

at S. D. Warren Company's

Foxboro Stock
increase

S. D. WARREN COMPANY
Warren's STANDARD CENTRAL MILL
Printing Paper Manufacturers



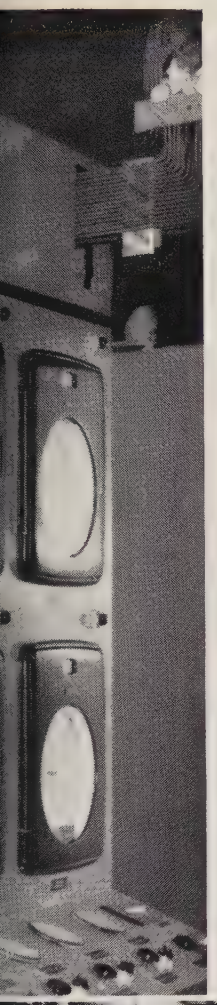
All four paper machines at Central Mill are equipped with Foxboro Stock Blending Systems. Control panels for Machines 3 and 4 are shown above. Machine superintendents report that because the Foxboro systems require less down time between runs, over-all production has been increased. Engineers and contractors for this program were Sumner Sollitt Company, Chicago.

Foxboro Magnetic Meters, 1/10 in., 3/16 in., an 1/2 in. diameter, control dye flows to mixin hoppers above each paper machine. Quick disconnect hose permits using same meters t serve several dye distribution headers. Dy proportions are set at control panel.

PHOTOGRAPHY BY JOHN W. MOORE, JR. — PITTSBURGH

Central Mill

Blending Systems cut waste, production of first quality paper



batch beaters eliminated . . . stock, dyes, additives blended continuously, automatically

More first quality paper . . . batch beaters completely eliminated . . . waste slashed. These are just a few of the cost reductions Foxboro Stock Blending Systems have produced at S. D. Warren's Central Mill, Muskegon, Michigan.

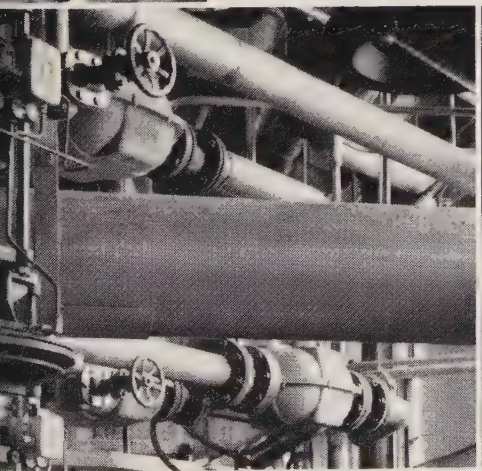
The unique Foxboro systems handle the whole job of stock proportioning. Machine tender sets desired stock, dye, and additive proportions on control panel for his machine — then walks away. Foxboro does the rest — blends pine, hardwood, broke, and purchased pulp; adds dyes and additives in proportions desired. System even adjusts for changes in machine demand while holding all proportions exactly constant. And it's all done continuously — automatically.

Foxboro Stock Blending Systems were installed on all four of Central Mill's Paper Machines as a major step in their continuing modernization program. Installation was handled by Foxboro during normal down-time periods so no production time would be lost.

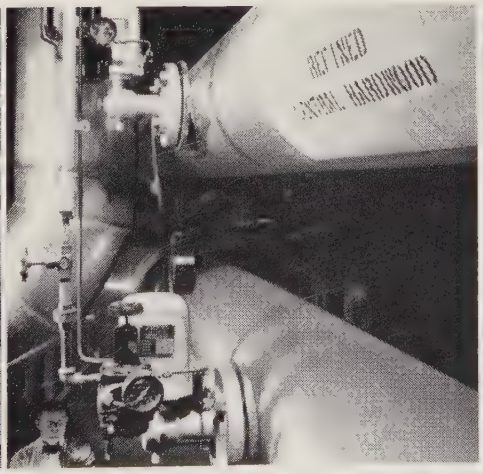
Everyone at Central Mill — from top management down — is extremely enthusiastic about the performance of these Foxboro systems. You'll be enthusiastic, too, when you discover how quickly they'll pay for themselves in your mill — through better quality paper — through increased production. Ask your Foxboro Field Engineer for full details. The Foxboro Company, 789 Neponset Avenue, Foxboro, Massachusetts.

FOXBORO

REG. U.S. PAT. OFF.

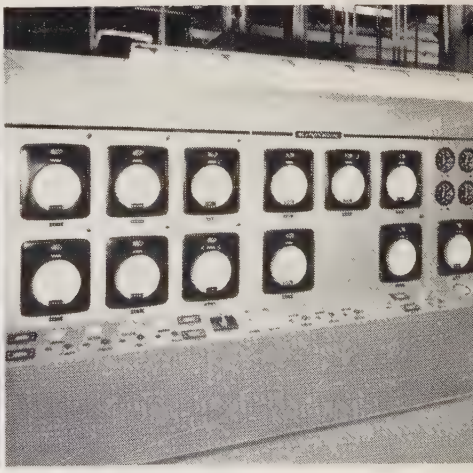


Foxboro Magnetic Meters, 3 and 4 in. diameter, control flow of stocks to blending chests — completely eliminate the need for batch beaters. Magnetic Flow Meters have no flow restriction of any type — cannot foul or plug up. Measurement is linear — accuracy guaranteed within ± 1%.



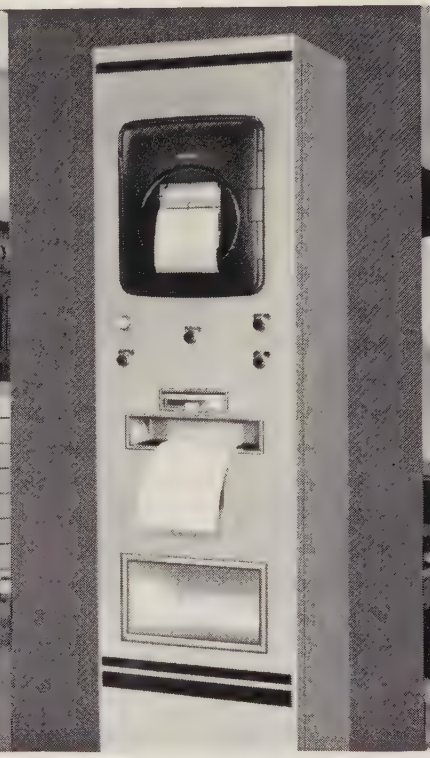
Foxboro d/p Cell* pressure transmitters are mounted right in the side of main feed-stock headers at the S D. Warren Mill. Precise operation of this entire blending system is assured by the accuracy and reliability of these sensitive pressure transmitters.

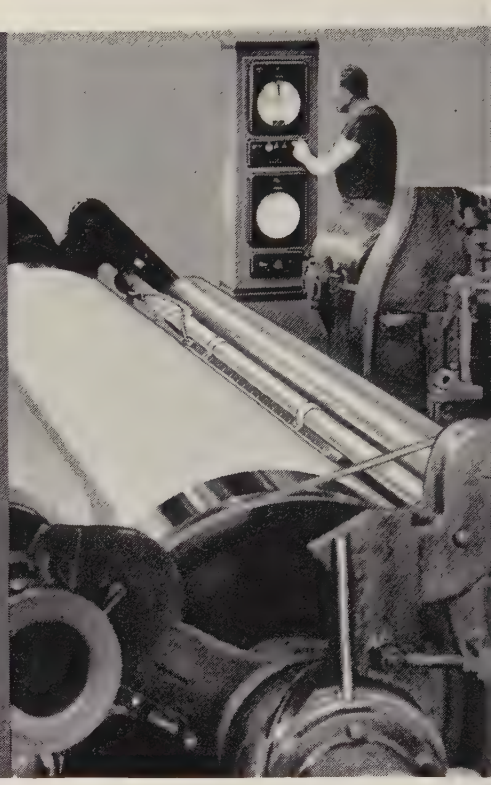
**Reg. U.S. Pat. Off.*



Foxboro instrument panel for #2 Machine gives operator complete control of the blending operation. On it are mounted flow-proportioning controllers for four stocks as well as for dyes and additives. Also, the percentage setting dials which proportion each stream to total system flow.

Other Foxboro Systems that can help you improve production in the 60's...





Foxboro Digester Control. Uniform pulp, cook after cook — is what you get with Foxboro Automatic Digester Control.

To start a cook, operator simply turns a single knob — and Foxboro takes over. Results: perfectly controlled digester circulation with virtually no liquor pull-over; uniform permanganate; practically no rejects. All automatic — from fill to blow — all resulting in high yield and excellent uniformity.

Foxboro Caliper Profiler. Put in a sample strip, push a button, and in a matter of minutes the Foxboro Caliper Profiler gives you a continuous chart record of sheet thickness — all the way across the sheet.

No time-consuming spot checks with hand micrometers — no awkward, cumbersome testing machines. The Foxboro Profiler shows you exactly where caliper is off — offers a new high in quality control.

Foxboro Sheet Moisture Control. Direct measurement of sheet moisture at the reel . . . fast, precise control of steam to the dryers . . . moisture control of any weight stock: tissue, pulp, kraft, newsprint, board or specialties. You get all this and more when you install the Foxboro Sheet Moisture Control System.

An invaluable aid to improved quality paper; to elimination of costly rejects; to shipping at precisely the moisture content specified.

REG. U.S. PAT. OFF.
Warren's
STANDARD

This advertisement is printed on Warren's Lustro 100#, manufactured at their Central Mill, Muskegon, Michigan

FOXBORO
REG. U.S. PAT. OFF.

S. R. CHRISTENSEN

Beloit Eastern's John Walsh

The day-to-day operation of a modern plant is an exacting job, one that requires men with diverse skills and wide experience. John Walsh, vice president and general plant manager of Beloit Eastern Corporation, is such a man. Well versed in all facets of plant management, he is in a position to see that each job receives the individual attention necessary to building the finest and most efficient of mill equipment. Your Beloit Eastern products have that "something extra" because John and his staff of experts are on the job. Look to Beloit Eastern to furnish you with the finest in finished product processing equipment.

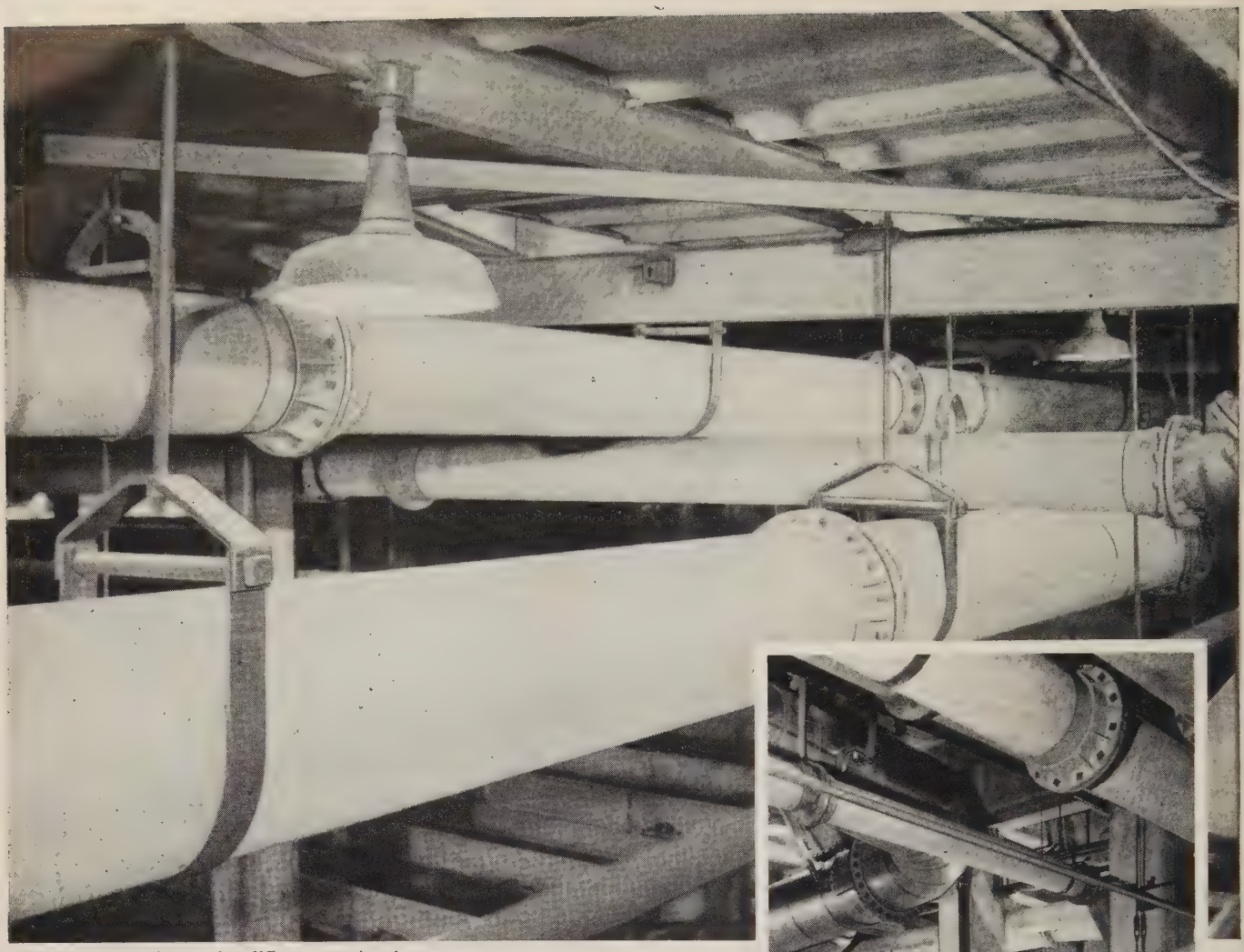
FINISHED PRODUCT PROCESSING EQUIPMENT

Winders • Petite Winders • Slitters Supercalenders • Roll Wrappers Roll Lowering Tables • Roll and Shaft Handling Equipment • Conveyors Unwind Stands and Tru-Tension Controls • and other equipment for the paper and allied industries.

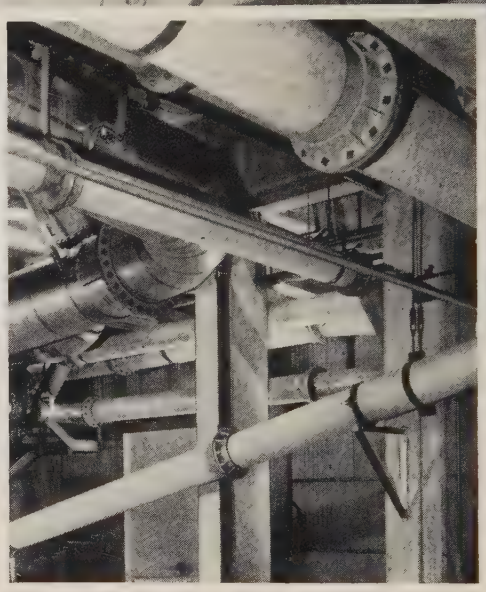
BELOIT EASTERN CORPORATION

DOWNINGTOWN, PENNSYLVANIA

Member Beloit Group



Transite Pipe performs nine different services in the St. Regis Company's Jacksonville Plant.



Transite line is from new mill washed stock chest to old mill washed stock chest.

Transite Pipe helps St. Regis work giant new "Seminole Chief" at full capacity!

Chief Engineer, L. C. Crowder, tells of experience with Transite . . . how its flow capacity and "cleanliness" determined its selection

Almost by the day, we see new reports on the added economy and performance that Transite® Pipe brings to water and stock lines. One such report comes to us from the St. Regis Company's Jacksonville Plant:

"When we recently installed the Seminole Chief, one of the largest capacity machines in the industry," says Mr. Crowder, Chief Engineer, Pulp & Paper Division, "production jumped from 300 to 1300 tons per day. And water capacity and stock cleanliness became more important than ever.

"Six years' experience with Transite Pipe told us it would do the job. It has an exceptionally smooth interior surface that offers minimum frictional resistance to the flow of liquids. Of equal importance, it is immune to tuberculation and is resistant to sliming and bacterial growths.

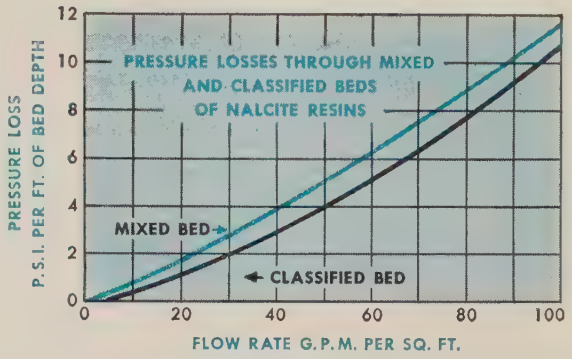
"For all those reasons we chose Transite Pipe for our entire system. Carrying water and stock in nine different types of lines, Transite helps us maintain an even and continual flow rate . . . with required stock cleanliness."

Proven installation economy, maintenance savings and resistance to stock build-up—make Transite Pipe well worth your investigation. Meanwhile, let us send you copies of TR-113A, a 24-page illustrated brochure and TR-180A, the Transite installation guide for process systems. Send for them today. Address Johns-Manville, Box 147A, New York 16, N.Y.

JOHNS-MANVILLE JM PRODUCTS

How to Make Your Demineralizers GROW: Replace Worn-out Resins with New Nalcite® Ion Exchangers

Added Capacity Teams With Higher Flow Rates, Less Pressure Drop, To Increase Demineralized Water Output at Low Cost



Demineralizers are like storage space—you can always use more capacity . . . And new Nalcite resins can help you get that added capacity from your present demineralizer installation.

"Better than new" is a practical prospect with Nalcite resins. They not only outperform older Nalcite ion exchange materials (which were as good as could be made at the time), but they also have longer useful life.

New Nalcite Resins Stay New

Nalcite HCR-W* cation and Nalcite SBR-P* anion exchangers were designed to eliminate the enemies of ion exchanger performance: strong resistance to bead breakage and loss, and organic fouling, keeps capacities up, resin addition down.

Nalcite SBR-P Anion Exchange resin has taken a leading place in the water demineralization field since its introduction in 1957. It is a strongly-basic anion exchanger with both high porosity and high capacity. While it is especially suited for waters containing organic matter and color, its high capacity and efficiency are good reasons to consider it as replacement for worn out type 2 as well as type 1 resins. It can be used effectively on all types of water supplies. Brine washing to remove organic matter and color has been eliminated in several demineralizers now using Nalcite SBR-P in place of older type resins. Excellent particle size characteristics add to the efficiency of Nalcite SBR-P. Optimum bead size facilitates foreign matter removal, minimizes expansion during backwash, and permits use of less freeboard in many installations. High flow rate mixed bed demineralization and applications which subject resin to considerable physical handling are other areas where Nalcite SBR-P has proved an outstanding performer.

Nalcite HCR-W* Cation Exchange resin has the high degree of sphericity and very narrow range of particle size distribution that assure low operating pressure losses in both mixed and classified bed demineralizers. Virtually stress-free HCR-W spheres reduce breakage due to regeneration, high flow rates or other causes—including drying. Nalcite HCR-W beads also resist channeling and packing. Nalcite HCR-W has excellent physical and chemical stability under most severe demineralizer operating conditions, plus high exchange capacity to make your demineralizers grow in efficiency for you.

Replace All or Part of Resin?

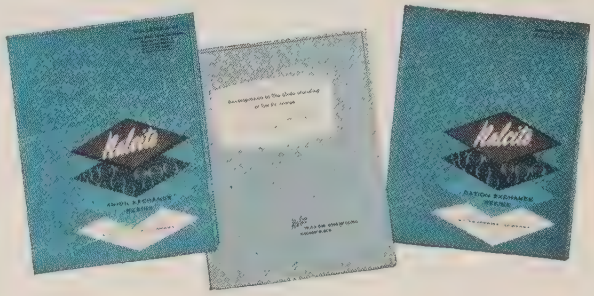
Replacement of entire beds with Nalcite SBR-P and HCR-W is the way to boost demineralizer performance and capacities to top efficiency. Partial bed replacement may be made with Nalcite HCR-W, regardless of the type of cation resin used, but due to possible density differences which may adversely affect anion exchanger performance, addition of SBR-P to other anion exchangers, exception in mixed beds, should be made only after study. To be sure of your replacement resin benefits, consult your demineralizer equipment manufacturer, who can engineer these new improved ion exchangers into your demineralizer. Write us if you have any questions.

Data on Ion Exchangers

Progress in the practical science of using ion exchangers efficiently is discussed in Nalco Reprint 84: "Developments in the Understanding of Ion Exchange." Practical ion exchanger applications, improved laboratory methods, new ion exchange materials, and more efficient operating technique are discussed.

New Nalco Bulletins: (HCR-W) Z12 and (SBR-P) Z13 provide extensive technical information on these efficient Nalcite Ion Exchangers. Your request for any or all bulletins will be honored promptly.

*Registered trademarks of Nalco Chemical Company.



NALCO CHEMICAL COMPANY
Ion Exchange Division
6197 West 66th Place • Chicago 38, Illinois
Subsidiaries in England, Italy, Mexico, Spain, Venezuela and West Germany
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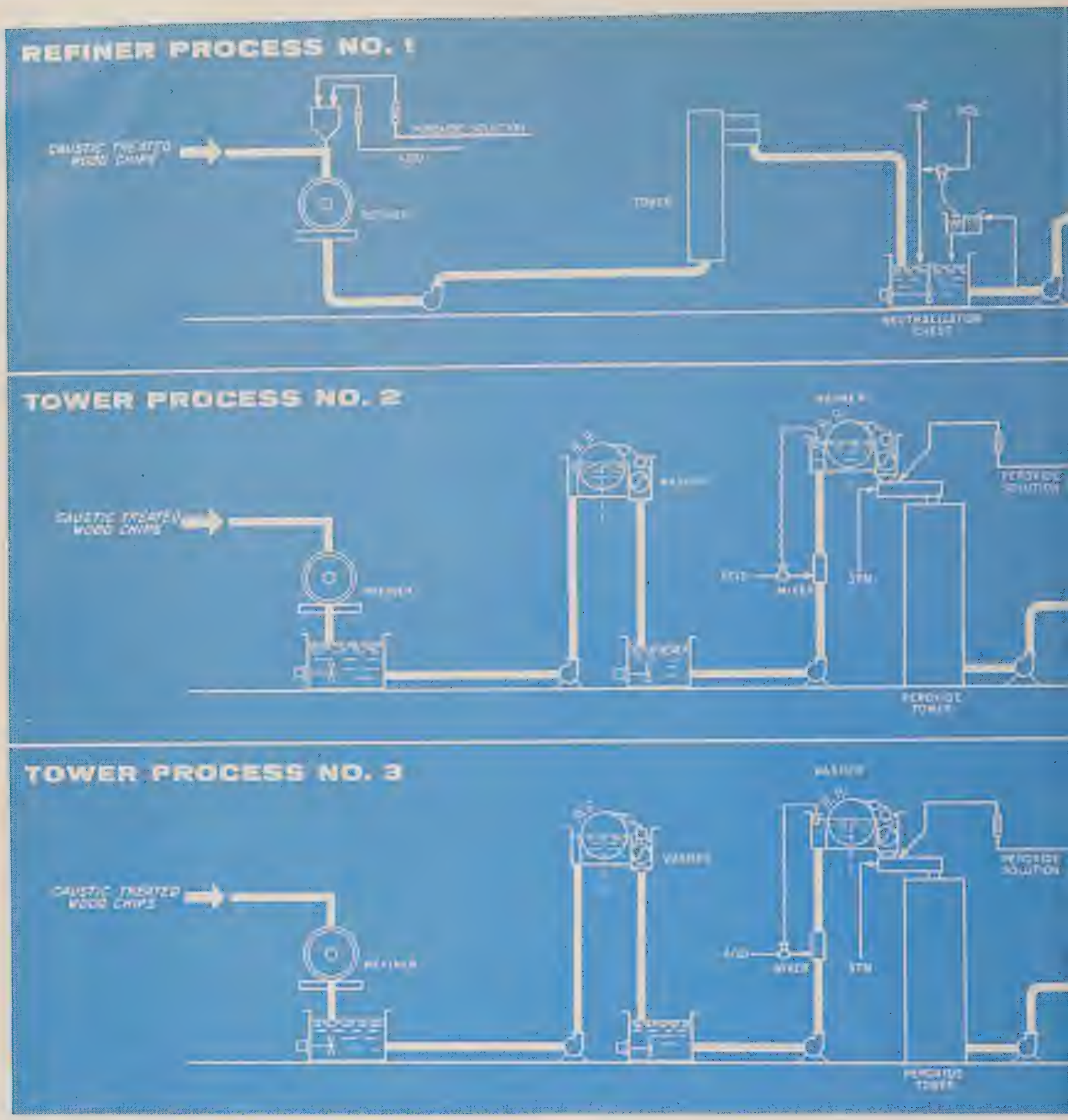
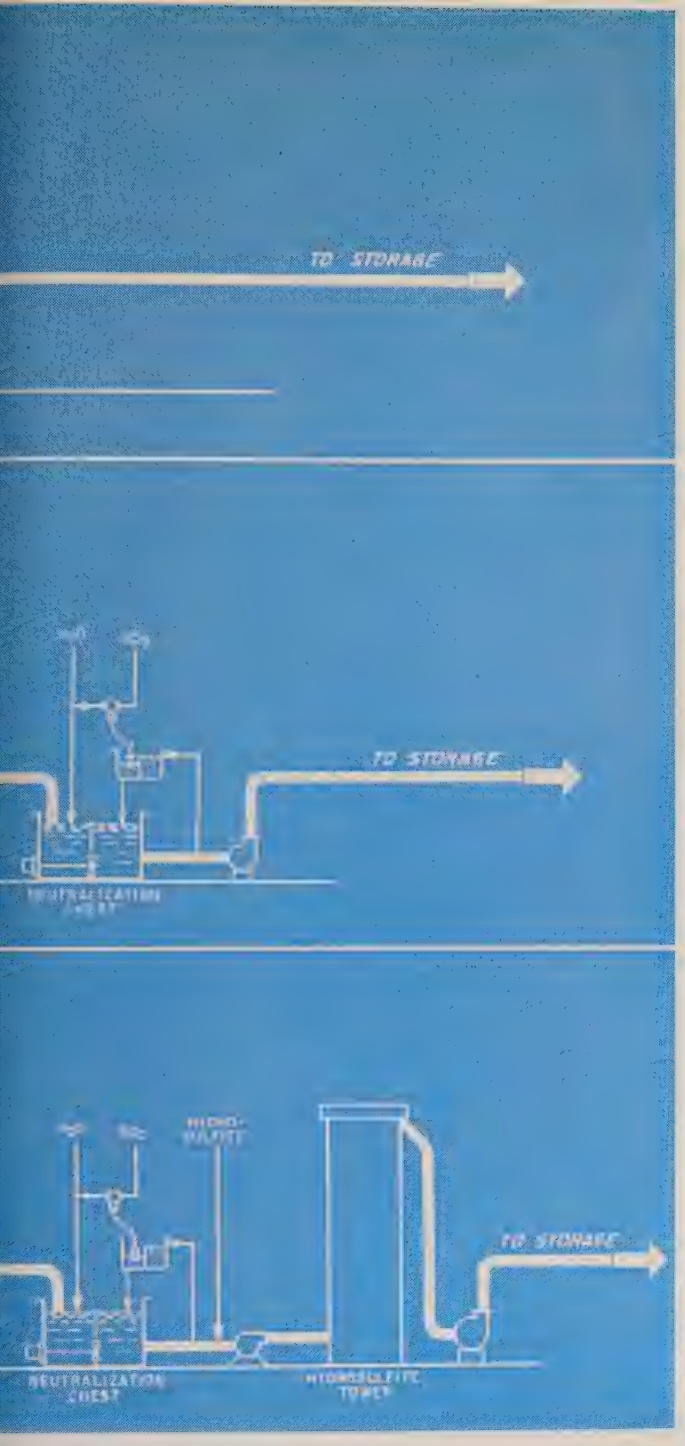
Nalco®... Serving Industry through Practical Applied Science



Which process is best for

experience can help you make the right ...and save you thousands of dollars in

CALL ONE OF THESE MEN ... LET HIM WORK WITH YOU IN MAKING THIS IMPORTANT DECISION:



Du Pont experience has helped many mills make the right choice between tower or refiner bleaching for cold caustic pulp based on brightness requirements. For example:

60 brightness. In process No. 1 at left, caustic-treated wood chips enter refiner and are bleached with "Albone" hydrogen peroxide and acid*. The use of acid controls the alkalinity of the bleaching reaction and assures maximum response from the hydrogen peroxide. Sulfur dioxide (SO_2) then neutralizes the bleached pulp and stabilizes the brightness obtained in the refiner. **Du Pont Patent Pending.*

65 to 75 brightness. In process No. 2 at left, pulp is refined, washed to remove caustic solubles, acidified with sulfuric acid to remove acid solubles, washed, and bleached in a conventional peroxide tower to desired brightness in the 65 to 75 range.

70 to 80 brightness. In process No. 3 at left, pulp goes through the same steps as in process No. 2. Then pulp is neutralized, and bleaching is completed in a hydrosulfite tower for maximum brightness in the 70 to 80 range.

Electrochemicals Department, Peroxygen Products Division
Wilmington 98, Delaware

ALBONE® hydrogen peroxide — DU PONT — **SOLOZONE®** sodium peroxide

BETTER THINGS FOR BETTER LIVING...*THROUGH CHEMISTRY*

bleaching cold caustic pulp? Du Pont choice between tower or refiner bleaching investment and chemical costs.

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New York & Boston Area
C. R. Lombard, New York, N. Y.—LOngacre 3-6440

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Or call: N. J. Stalter, Wilmington, Delaware—PRospect 4-4698

MOVING INTO YOUR FUTURE . . .

. . . A NEW PAPER MACHINE

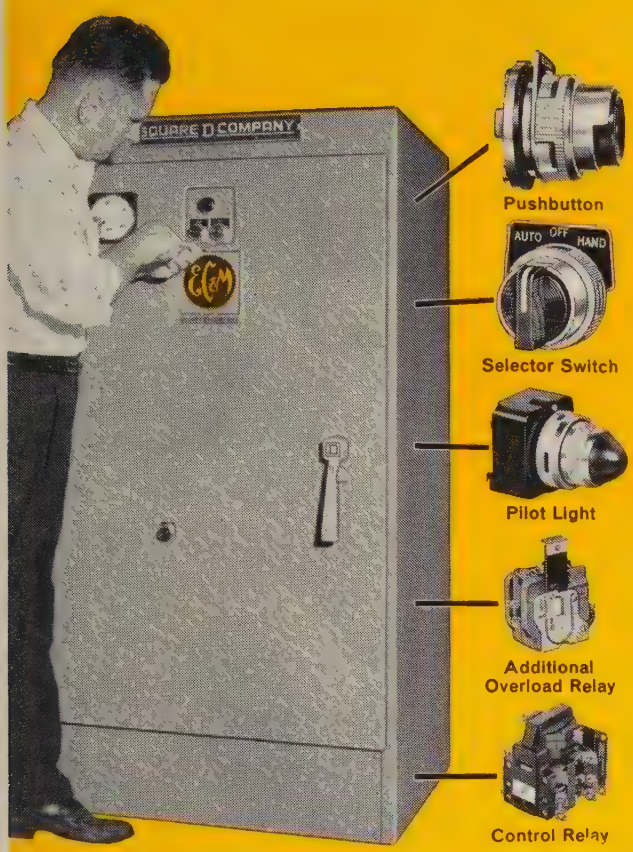
NICOLET PAPER COMPANY'S
NEW 160" NO. 3 MACHINE

by . . . VALLEY

VALLEY IRON WORKS CORPORATION
SUBSIDIARY OF ALLIS-CHALMERS MANUFACTURING COMPANY
APPLETON, WISCONSIN

West Coast Representative: E. A. Berry, P.O. Box 958, Longview, Washington
Canadian Representative: Pulp and Paper Mill Association Ltd., P.O. Box 850, Station "O", Montreal 9, Quebec

FAST DELIVERY of SIZE 6, 7 & 8 STARTERS



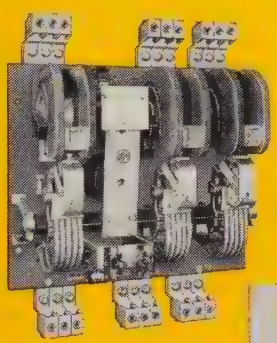
PRE-ENGINEERED MODIFICATIONS eliminate Special Engineering

Square D NEMA Size 6, 7 and 8 magnetic starters are now built with a plate in the door to accommodate modifications when needed. The same modifications which have long been available on Square D starters through Size 5—pushbuttons, selector switches, pilot lights, additional overload relays, auxiliary contacts—can now be added to the larger starters without special engineering.

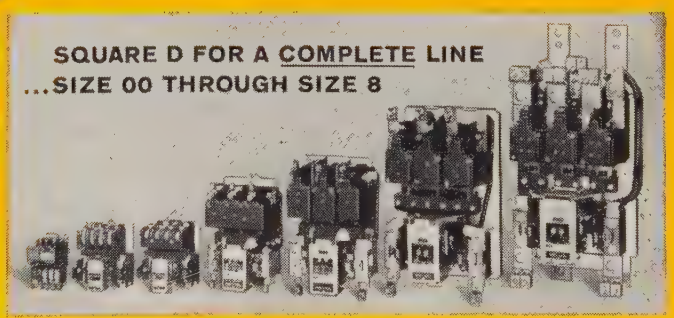
This means fast processing of your order, quick delivery of your starters. What's more, you can make the same modifications in the field. The wiring diagram shipped with each starter shows exactly how to do it.

Available in ratings up to 900 hp, Square D Size 6, 7 and 8 starters can be ordered as open devices, or in general purpose, dust-tight and water-tight enclosures.

• With Square D Size 6, 7 and 8 starters, you get DC-operated (self-contained DC supply) mill-type contactors—at no extra cost. Exclusive Line-Arc construction dissipates heat, provides longer contact life. Self-lubricating bearings plus simple design make maintenance extremely easy. Another standard feature is lugs which accommodate either copper or aluminum cable.



• The magnetic starters shown at right—which range from Size 00 through Size 5—plus the Size 6, 7 and 8 starters described above, add up to a *complete* Square D line for *any* AC motor application.



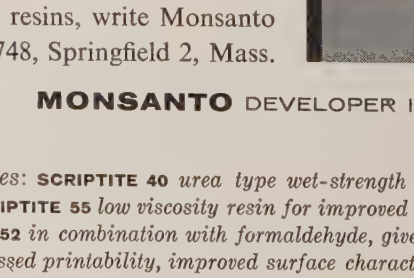
Write for Bulletin 8536. Square D Company, EC&M Division, 4500 Lee Road, Cleveland 28, Ohio

SQUARE D COMPANY
EC&M DIVISION • CLEVELAND 28, OHIO

wherever electricity is distributed and controlled

5291

this
paper
was
treated
with



SCRIPTITE* 33

*SCRIPTITE, LYTRON: Reg. U. S. Pat.

Monsanto Scriptite 33—a melamine resin supplied as a dry fine powder—imparts high wet strength to many paper products. It increases wet bursting strength, dry tensile strength, wet rub resistance . . . improves dry stiffness, dry mullen, folding endurance, wax pick, dimensional stability. Monsanto offers a wide range of Scriptite resins for increasing the wet strength and water resistance of paper and board. Also available are Monsanto Lytron resins, water dispersal resin polymers, for efficient paper and board coating. For complete information of Scriptite 33 and other Monsanto paper resins, write Monsanto Chemical Company, Plastics Division, Room 748, Springfield 2, Mass.

Monsanto

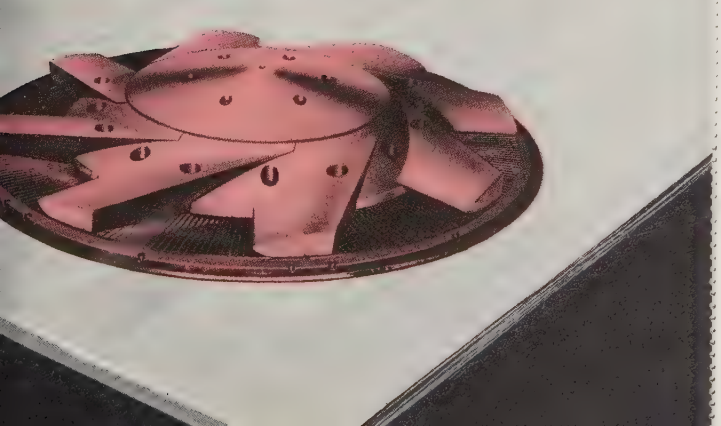
MONSANTO DEVELOPER IN **PLASTIC**

The Monsanto line of paper resins also includes: **SCRIPTITE 40** *urea type wet-strength resin.* **SCRIPTITE** *water-insoluble adhesive for paper and liner board.* **SCRIPTITE 55** *low viscosity resin for improved water resistance, and dry rub resistance with easy handling.* **SCRIPTITE 52** *in combination with formaldehyde, gives water resistance folding boxboard and jute liner.* **SCRIPTITE 50** *unsurpassed printability, improved surface characteristics on boxboa* **SCRIPTITE 45** *new thermosetting resin for stabilization of paper.* **LYTRON*** *water dispersal resin polymers for coatin*

BLACK-CLAWSON

Project file:
The Vokes Rotor

Released by Research J.B.



THE VOKES ROTOR

outperforms a standard Hydrapulper® 2 to 1... pulps and de-
fibers to 100% SDS*

(See other side of page)

*Shartle Defibering Standards

FIRST CLASS
PERMIT NO. 5
SEC. 34.9 P.L.&
MIDDLETOWN, OH

BUSINESS REPLY CARD
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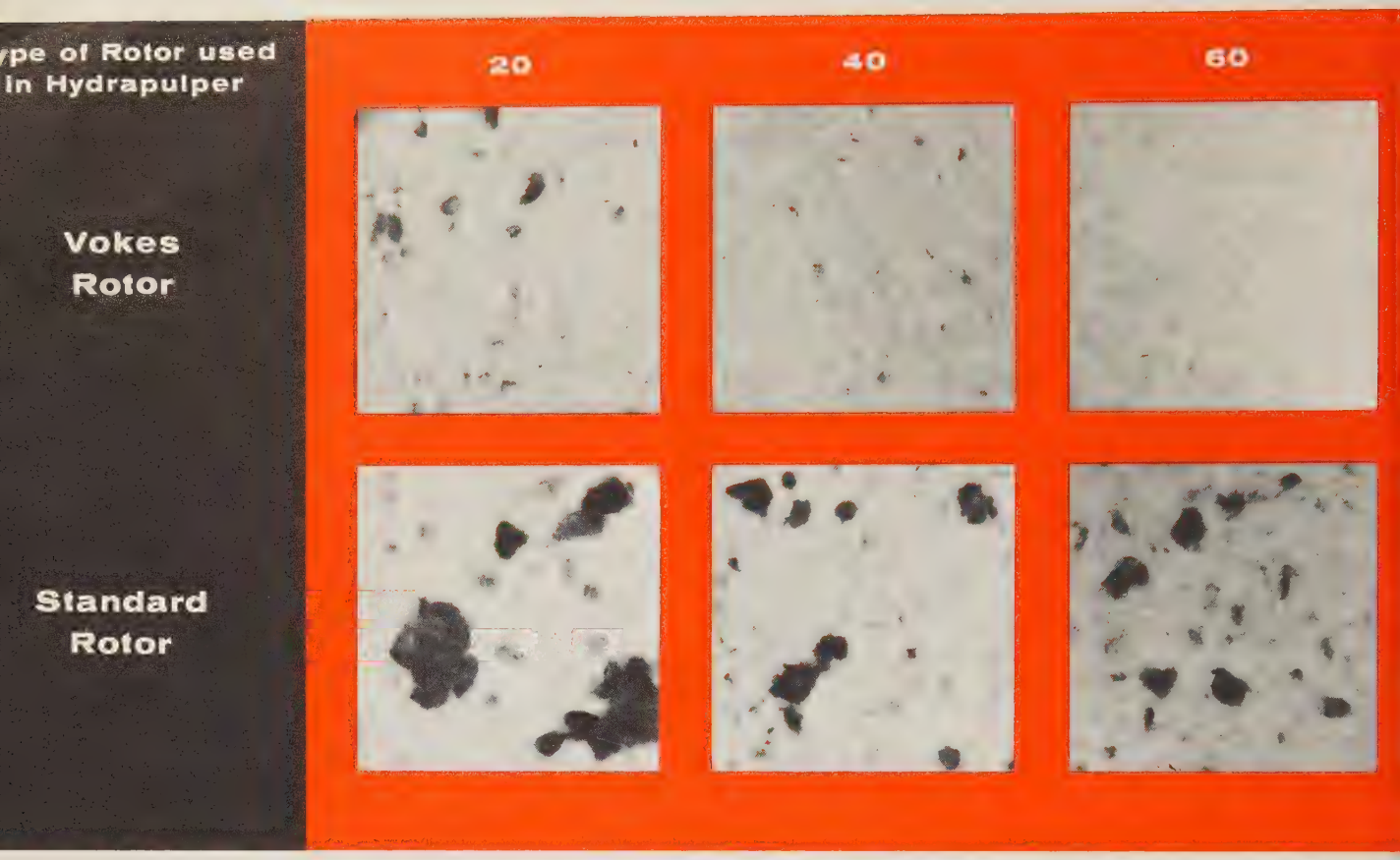
THE BLACK-CLAWSON COMPANY
SHARTLE DIVISION
MIDDLETOWN, OHIO

Typical Performance...
Highly sized Kraft Clippings



THE VOKES ROTOR*

gives top performance in

- Power Economy
- Submergence
- Blending and Mixing

Unsurpassed for

Broke, bale and bulk furnishes,
Split rolls, slab and sheet trim
Wet strength and separation of wood fibers from various poly-coatings.

Offered as conversion unit for existing Hydrapulpers and as standard equipment on new Hydrapulpers

Want greater defibering efficiency? Send for a copy of Bulletin 27-SB "The Vokes Rotor."

GET THE FULL STORY.

MAIL THIS CARD TODAY!

HE BLACK-CLAWSON COMPANY
HARTLE DIVISION, MIDDLETOWN, OHIO

lease send me Bulletin 27-SB and other data on the Vokes Rotor

ame_____

itle_____

ompany_____

ddress_____

ity_____ State_____

anyone for lunch?

Should your paper mill "menu" offer sugar . . . gum . . . amino acid . . . casein . . . glue . . . you can be sure that such slime-causing eager-eaters as *Bacillus megatherium* or *Bacillus subtilus* are just waiting to move right in and cause a whole host of problems.

But you can do something about it *now* to head off or control existing slime problems through the use of an *effectively* planned program of microbiological control . . . *ONE* of the many services offered by Betz Laboratories. For over 35 years, Betz has provided a specialized consulting engineering service to the paper industry, including the use and application of slime control agents, pitch dispersers, anti-scaling agents, retention aids, filming amines, corrosion inhibitors, and deinker aids.

Bulletin 592 discusses the Betz *specialized* approach to microbiological control. Write for a copy, there's no obligation.

BETZ LABORATORIES, INC., Gillingham & Worth Streets, Philadelphia 24, Pa.

In Canada: BETZ LABORATORIES LIMITED, Montreal 1.

BETZ

CONSULTANTS ON MICROBIOLOGICAL CONTROL

COLTON FLEXAC

upgrades packaging board to premium quality...at far less than premium cost

COATINGS FOR BOXBOARD AND PAPER IMPROVED WITH THE NEW COLTON SERIES OF HOMOPOLYMER PVAc EMULSIONS ARE OUTSTANDING FOR EXCELLENT LIGHT STABILITY...LOW ODOR LEVEL...GOOD PICK RESISTANCE

If you make packaging board, it will pay you to investigate Colton's new Flexac series of homopolymer polyvinyl acetate emulsions for upgrading print base coatings.

Flexac, a giant step ahead for the expanding boxboard industry, is a synthetic polymer offering the ultimate in light stability, a highly-desirable lower odor level and good pick resistance . . . at a price substantially lower than that of comparable-quality binders.

You and your customers are naturally interested in printability. The ready-to-use Flexac series has been developed to provide unexcelled printability . . . and machinability as well.

Colton Chemical Company's Supervisor of Paper Technical Service conducting IGT pick test at Air Reduction Company, Incorporated, Central Research Laboratories, Murray Hill, N.J.

COLTON

COLTON CHEMICAL COMPANY

A Division of Air Reduction Company, Incorporated • 1747 Chester Avenue, Cleveland 14, Ohio
Sales Offices and Warehouse Facilities Throughout U. S. • Export: Airco Company, International, New York 17, N.Y.

AT THE FRONTIERS OF PROGRESS YOU'LL FIND . . .

AN AIR REDUCTION PRODUCT

Dryden=Quality

Quality=Dryden

Our customers tell us:

"Dryden is the new standard by which all pulps are compared."

At trade conventions, when the subject of "Quality" comes up, paper men always *start* with talk of Dryden.

As one customer recently told us, "Dryden is the new standard by which we compare all other pulps. When a new pulp comés along, our research people compare it with Dryden."

Our friend was referring to Dryden Bleached Sulphate Pulp, but the same can be said for Dryden's unbleached, electrical, and other specialty pulps.

Whether you want strength, or brightness, or cleanliness, or purity, Dryden pulps are unsurpassed.

Have you checked the "QUALITY=DRYDEN" equation in your own laboratories?

DRYDEN PAPER COMPANY, LIMITED
DRYDEN, ONTARIO, CANADA

SOLD BY: **Anglo Paper Products, Ltd.**
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SALES REPRESENTATIVE IN THE UNITED STATES:
Northeastern Paper Sales, Inc.
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FROM DU PONT RESEARCH . . .

The first Titanium Dioxide Pigment

COMPARISON OF RETENTION PROPERTIES between "Ti-Pure" HR and conventional TiO_2 is demonstrated by Dr. Harold C. Brill, Paper Section Manager, at the Du Pont Pigments Department, Technical Service Laboratory. Mixtures of chlorinated starch and pigment were prepared and then poured through filter paper. Note particles of the conventional pigment have run through the filter paper in left test tube, while the HR filtrate in the right test tube remains clear. HR has not passed through the paper. Your Pigments Representative will perform this desk-top experiment for you in your plant, if you wish.

expressly designed for wet-end addition

TI-PURE® HR

offers high one-pass retention...cuts pigment costs up to 15% in the presence of starch

Now you can cut the amount of titanium dioxide pigment added in the wet-end and still give uniform high brightness and opacity to bond, offset and other quality printing papers. The reason is new Du Pont "Ti-Pure" HR—the first titanium dioxide pigment developed expressly for papermaking.

"Ti-Pure" HR offers better one-pass retention in the presence of oxidized starches than any other pigment. (The HR stands for High Retention.) In systems without starch, HR has retention equal and sometimes superior to commonly used beater-grade pigments.

Plant run shows difference in retention

In a typical plant run, the titanium dioxide content of finished sheets showed these differences: conventional titanium dioxide plus a retention aid, 5.0%; "Ti-Pure" HR, under optimum conditions, 6.4%.

This superior retention naturally means less pigment loss to the sewer, less load on save alls. Several mills that have recently switched to "Ti-Pure" HR report savings up to 15% in pigment costs.

HR has unique properties

"Ti-Pure" HR is a water-dispersible pigment that can be added dry, or used in mills with wet slurry systems. It has outstanding suspension properties, minimizing the problem of settling in the float chambers of the metering pump. HR is not flocculated until alum or other flocculating agents are added and offers opacity and brightness, dry or waxed, similar to commonly used beater grades of anatase TiO_2.

RESULT: BETTER CONTROL over the pigment content of your papers, more uniform paper quality. Let your Du Pont Pigments Representative tell you about "Ti-Pure" HR. He'll run a demonstration for you that dramatically compares the retention qualities of HR with a standard pigment (see picture left).

E. I. du Pont de Nemours & Co. (Inc.)
Pigments Department, Wilmington 98, Delaware

TI-PURE® HR

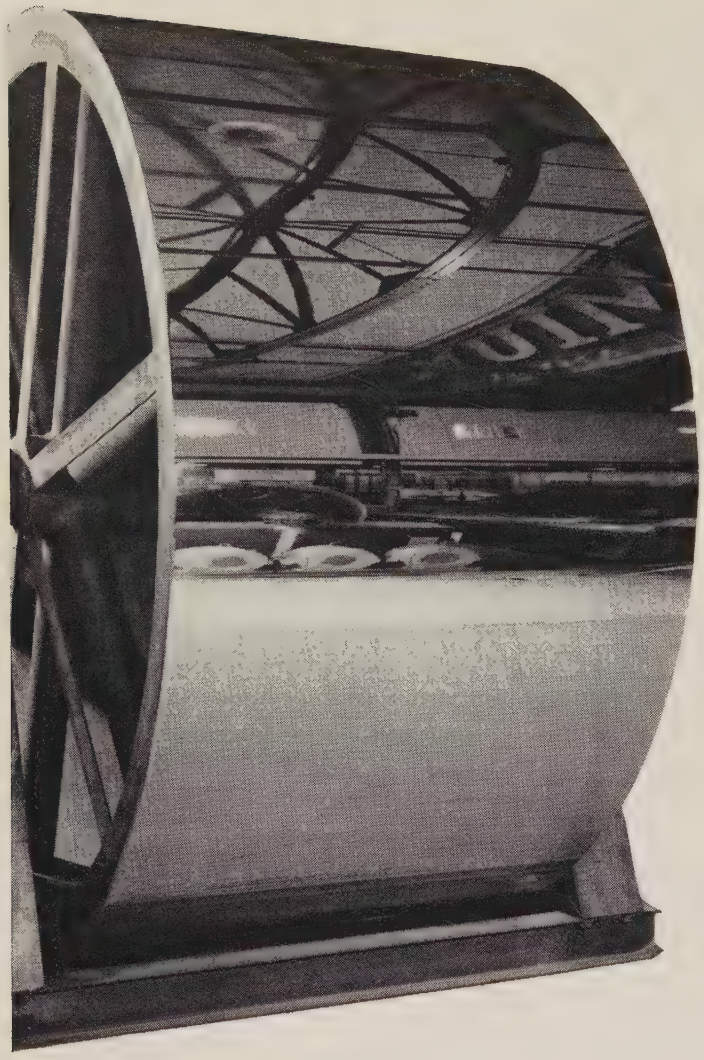
(Titanium Dioxide Pigments)

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

FINISH...

the prelude to PERFORMANCE



This dryer drum 12′ D x 75″ Face is CRODON-plated directly upon steel for hardness and durability.

The performance of your dryer drums deserves that extra fineness of best-surface-finish which vitally affects the quality of the paper you sell. There is more than simple help to be gained in your production from CRODON-plating—there is the more direct benefit of improved quality of your paper that helps your product in the market place.

For more than 30 years CRODON-plating has been applied to drum surfaces to provide operating efficiency and lowered long-range costs. These years of experience emphasize five of the benefits of the CRODON surface **finish** and its contribution to your machine **performance:**

Cleanliness	Assures freedom from rust and consequent staining.
Hardness	Gives economical long life through its durability and wear resistance.
Thermal Suitability	Provides uniform and high-performance conduction heat-transfer.
Adaptability	Enables select textured or mirror finishes tailored to product requirements.
Imprint	Fulfills a need for better finishes imparted to paper, a boost in quality for you to market.

Need this kind of help? Invite the CRODON man.

CRODON
The Chrome Plate
TRADE MARK REG U.S. PAT. OFF.

Behind every CRODON application are the resources, experience and reputation of America's oldest, largest and most progressive industrial chromium plating organization.

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Executive Offices: 100 Park Avenue, New York 17, N. Y. **General Offices:** Rahway, N. J.

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for packaging adhesives from Borden!

Bags, cartons, cases, cups, films, foils, labels, laminates . . . whatever your bonding requirements, there is a Borden adhesive designed to provide operating advantages. Each grade has been perfected in Borden's research and development laboratories, and proven by performance in production applications. Consider Borden when looking for the *right* packaging adhesives . . . Borden know-how is available to help you do a better job. Write for a copy of Borden's Packaging Adhesive Index: The Borden Chemical Company, Resins and Chemicals Dept. T-90, 350 Madison Avenue, New York 17, N.Y.

THE BORDEN CHEMICAL COMPANY ©TBC

© The Borden Company

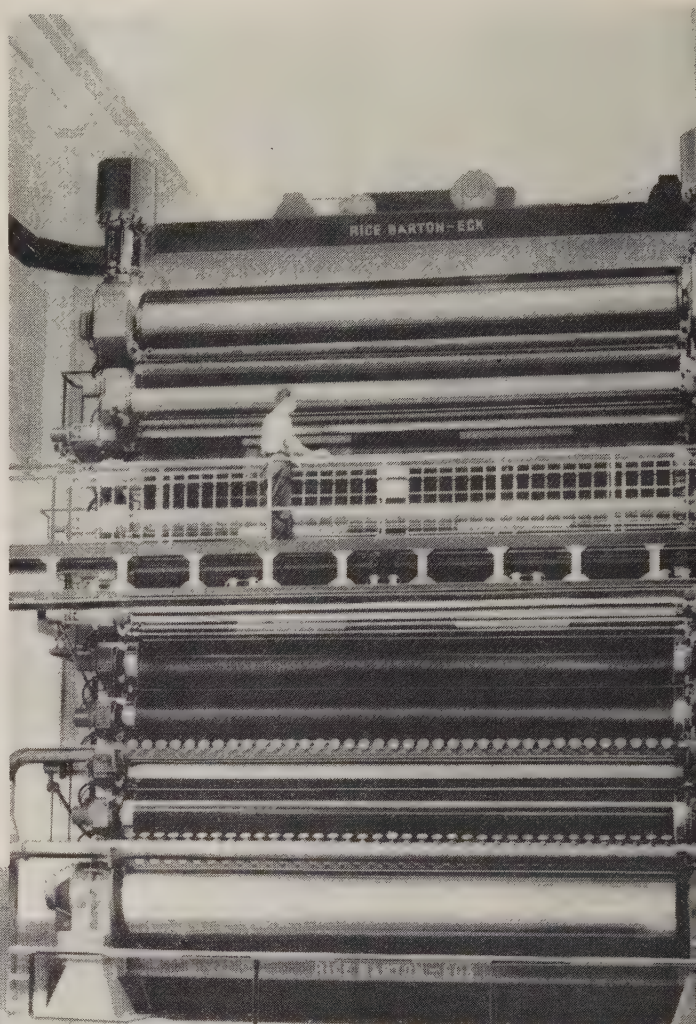
The BIG name in Stacks

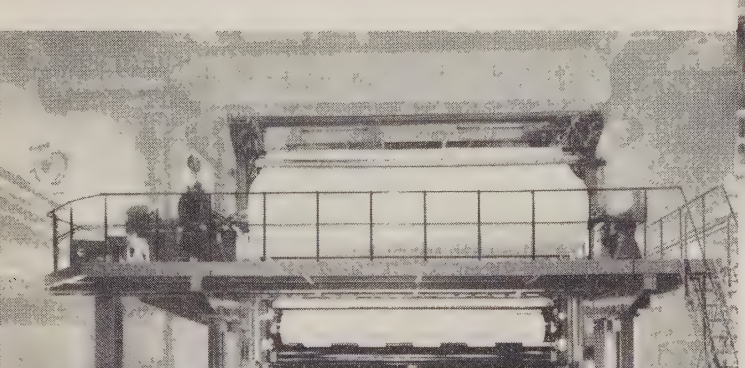
RICE BARTON-ECK builds HIGH SPEED SUPERCALENDERS BIG and builds them often. More than one supercalender a week was installed last year and over 350 have been installed in the past ten years.

This giant 230″ stack is designed for production speeds up to 2500 f.p.m. and nip pressures up to 2000 pounds.

Here are the reasons RICE BARTON-ECK supercalenders are superior:

- High strength open front frames for faster roll changes
- Elevators both sides for easier threading and safer operation
- Hydro-pneumatic pressure system with electric automatic controls
- Unwind and rewind tension control, center or surface type with special roll handling equipment
- Automatic pressure release and quick roll lift





Above—Open front view indicates easy access to rolls. Bea
ings and housings come off with rolls, housings gibbed to frame
Elevators on both sides of stack are synchronized with threadin
speed.

Shown left—Closed side shows semi-automatic loading ar
unloading of rolls and reels. Unwind and wind-up by electr
tension control. Control desk for electric and hydraulic system

For descriptive folder write today to

Rice Barton CORPORATION • WORCESTER, MASS.

FOURDRINIERS, PRESS SECTIONS, DRYER SECTIONS, CALENDERS AND SUPERCALENDERS, REELS, WINDERS, HEAD BOXES, SIZE PRESSES, BREAKER STACKS, DIFFERENTIAL DRAW CONTROL DRIVES AND CONE PULLEY DRIVES, PULPING EQUIPMENT, HIGH VELOCITY AIR DRYERS, TRAILING BLADE COATERS, FIBRE-FLASH DRYING SYSTEMS

RICE BARTON ECK

PAPER
NEWS
from
Allied
Chemical
• dyes for tinted book papers
• new California alum plant
• chlorine safety program
• super-high-gloss coatings

- *eye strain eased by new tinted book papers colored with Allied Chemical paper dyes*

White paper reflects as much as 93-95% of the light — black ink 3%. New color-coordinated papers and inks, like those used in this insert, reflect only about 75% and 10% respectively — sufficient contrast for easy reading *without* fatigue, according to leading color experts.

Cost-conscious manufacturers of tinted papers are using National® "tailor-made" paper dyes. National Paper Dyes give you modern dyestuffs designed for continuous dyeing, dry application and other money-saving techniques. Why not let a National representative show how these dyes can save money for you?

NATIONAL ANILINE DIVISION

This entire insert is printed on 80 lb. Appleton Coated Impact azure blue; ink is black. Yet, note how your eyes see "highlights" in this picture.

PLANTS:
Atlanta, Ga.
Barnet, B. C.
Chillicothe, O.
Cleveland, O.
Denver, Colo.
Detroit, Mich.
E. St. Louis, Ill.
Hopewell, Va.
Jacksonville, Fla.
Johnsonburg, Pa.
Kalamazoo, Mich.
Kennewick, Wash.
Macon, Ga.
Marcus Hook, Pa.
Menasha, Wis.
Middletown, O.
Monroe, La.
New Orleans, La.
Pine Bluff, Ark.
Port Arthur, Ont.
Port St. Joe, Fla.
San Francisco (Port Chicago), Calif.
Savannah, Ga.
Tacoma, Wash.
Thorold, Ontario
Valleyfield, Quebec
Vancouver, Wash.
Wisconsin Rapids, Wis.
And now . . .
El Segundo, Calif.

- *Allied Chemical adds new unit to network of strategically located alum plants*

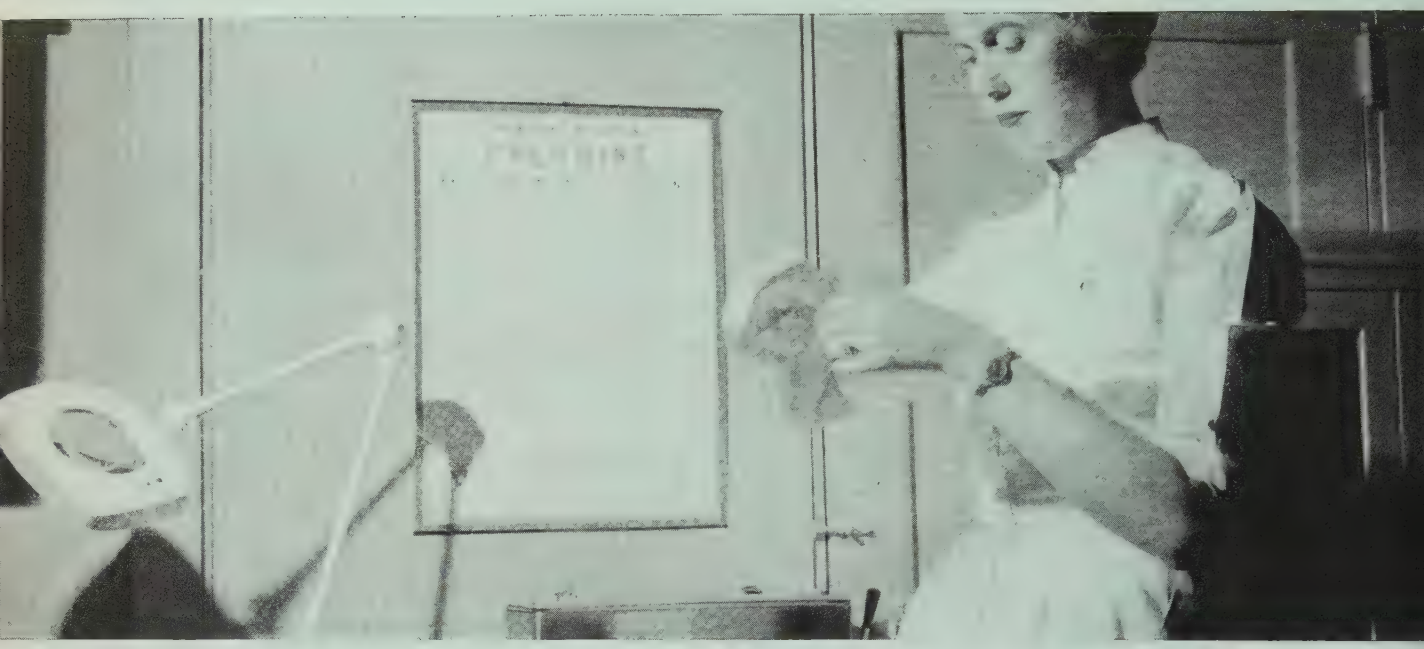
One of America's primary producers of aluminum sulfate, our General Chemical Division has just placed in production its 29th alum plant.

The new facility, situated near Los Angeles, will supply *liquid* alum — a form of the product pioneered by General Chemical — to paper mills and other consumers in the Southern California area.

Each unit in General Chemical's coast-to-coast network of alum plants is located in the heart of an active consuming area . . . providing paper makers with a close, convenient source of alum, liquid or dry. In addition, General's chain of warehouses makes dry alum immediately available in every major center of commerce. Write or phone for further information on how these facilities can serve you.

GENERAL CHEMICAL DIVISION

• *how Solvay helps customers with complete ch*

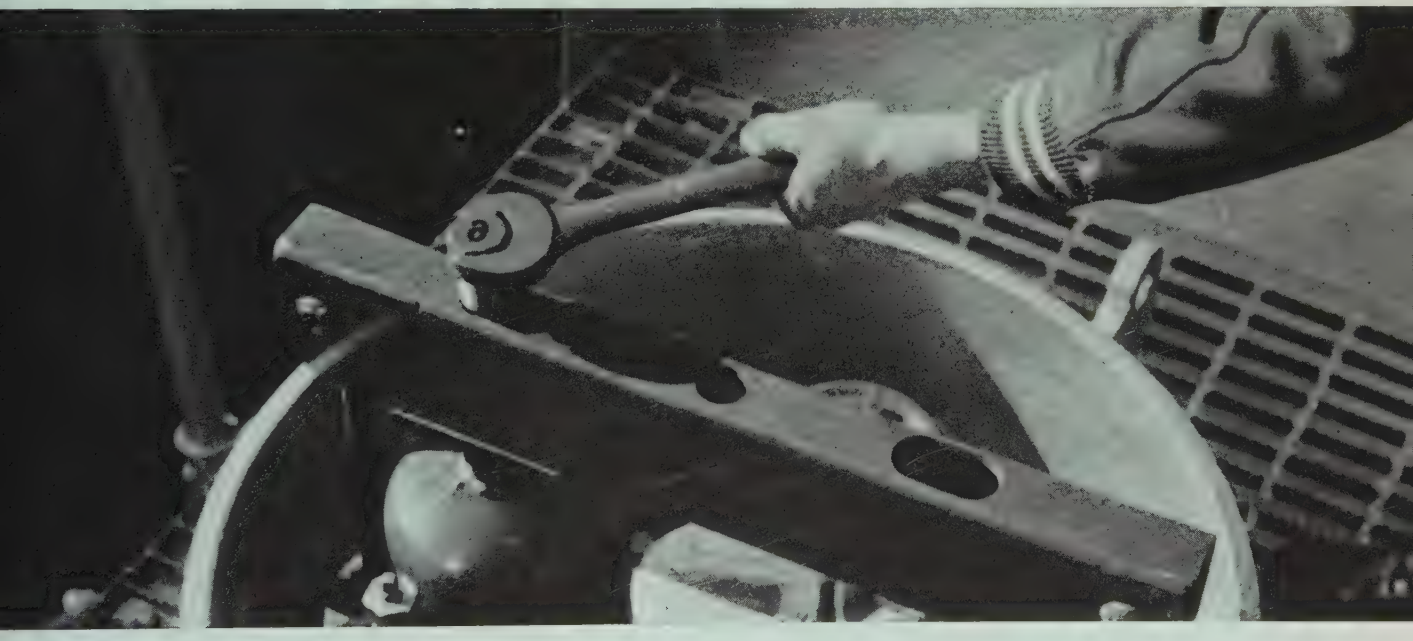


Safety posters list precautions to be taken in handling chlorine and procedure in case of accidents. Safety manuals, films and educational literature are also provided.

Solvay provides consultation on chlorine safety facilities and procedures. Here, technical service representative explains use and care of protective clothing.

program

Employees clear "danger" area in emergency drill. Safety training of personnel is another important facet of Solvay's integrated safety program for customers.



Equipment from a Solvay Chlorine Emergency Kit being used to stop leakage in tank car dome. Similar kits are available for 150-lb. cylinders and one-ton containers.

Photos on this page show several phases of a typical program in operation at a customer's plant. If you are a user of chlorine, the same service is available to you. Ask for information. ■ **SOLVAY PROCESS DIVISION**

• *new super-high-*

board coatings now make overwrappings unnecessary

A new heat treatment using A-C Polyethylene developed by Semet-Solvay imparts *super* high gloss to waxed paperboard...lets you dispense with overwrapping in many cases. It's ideal for frozen food and ice cream packages...butter and oleo...bread wrappers.

You can use this new technique while realizing all the advantages of A-C Polyethylene wax coatings: greater resistance to grease, moisture, scuffing and abrasion...smooth plastic-like feel...positive lock at freezing temperatures... brighter printing effects.

For details on *super* high gloss with A-C Polyethylene, write us.

SEMET-SOLVAY PETROCHEMICAL DIVISION

• *basic to America's progress*

Allied Chemical

For more information, write
Allied Chemical Corporation, Dept. 90-PA
61 Broadway, New York 6, New York.

In Canada:
Allied Chemical Canada, Ltd.,
1450 City Councillors Street, Montreal

• *principal products for the paper industry*

BARRETT DIVISION—BARRETT building materials.

GENERAL CHEMICAL DIVISION—Aluminum sulfate; Glauber's salt; Salt cake; Sodium silicate; Sulfuric acid.

NATIONAL ANILINE DIVISION—Adipic acid; CAPROLAN polyamide fiber; Fumaric acid; HARMON pigments for printing inks; Maleic anhydride; NACCONATE diisocyanates (in coatings); NACCONOL detergents and emulsifiers; NACCOTAN dispersing agent and mordant; NADONE cyclohexanone; NATIONAL paper dyes; Phthalic anhydride.

NITROGEN DIVISION—Ammonia liquor; Anhydrous ammonia; Formaldehyde; Methanol; Polyethylene glycol; Triethanolamine; U. F. Concentrate-85; Urea.

PLASTICS AND COAL CHEMICALS DIVISION—CUMAR resins; ELASTEX plasticizers; Fiber pitch; PLASKON urea resins, Solvents, Tar acids.

SEMET-SOLVAY DIVISION—A-C polyethylenes—Emulsifiable for paper size or coating; hot melt low molecular weight for coatings.

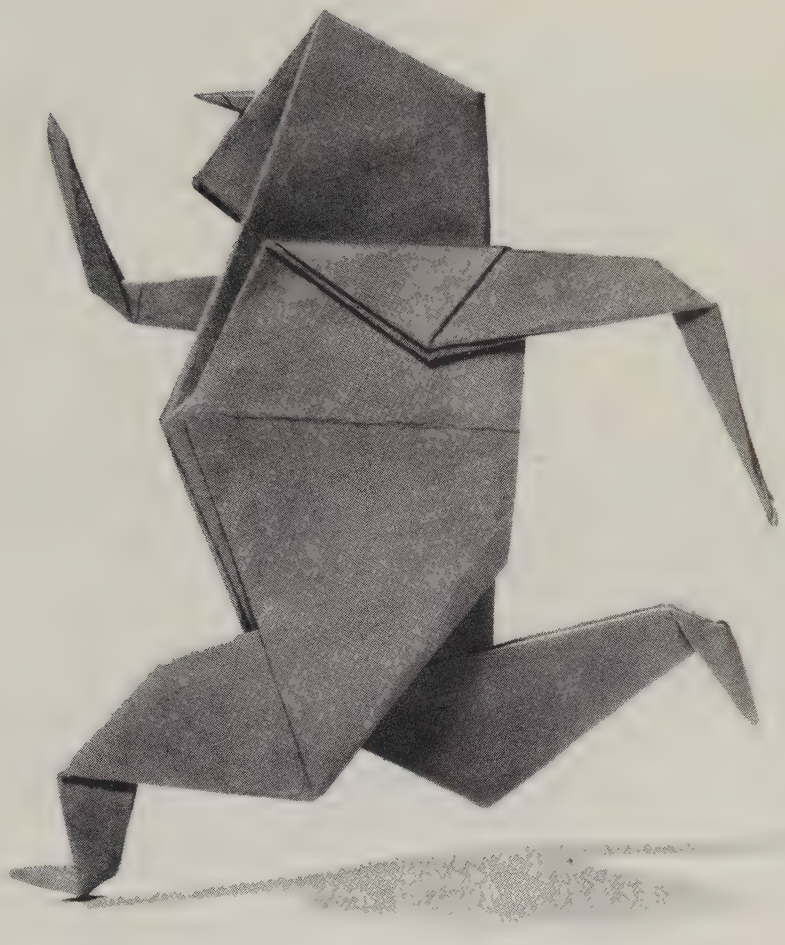
SOLVAY PROCESS DIVISION — Ammonium bicarbonate; Calcium chloride; Caustic soda; Chlorine; Hydrogen peroxide; MUTUAL salt cake; Soda ash.

INTERNATIONAL DIVISION—Marketing Allied Chemical products abroad.

Items above appearing in light face capital letters are Allied Chemical trademarks.

Printed in

Paper sculpture by Giuseppe Baggi



Pulp from Gottesman means...

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Bleached and Unbleached Sulphite • Bleached Hardwood • Groundwood
Bleached, Semi-Bleached, and Unbleached Kraft

GOTTESMAN–CENTRAL NATIONAL ORGANIZATION

WOOD PULP

PULP PAPER EXPORT CNC

Established 1886

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Central National Commercial Company, Inc.
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Gottesman & Company Aktiebolag, Stockholm, Sweden • Central National-Gottesman Limited, London, England • Representatives in 55 Leading World Markets

KEEVER VICTOR STARCH

a blend of QUALITY STARCHES made to meet your EXACT requirements

How often do your paper-making problems point the finger to starch problems?

Then get acquainted with Keever — and Victor Starch. It's the only blend of wheat and corn now available to the paper industry.

Tests prove that Victor Blended Starch provides a clearer film, greater adhesive strength, more flexibility, a better fiber lay.

Victor Starch makes it possible to produce a formula best suited to nearly every starch operation in paper making.

Keever starch technicians will help you work out the ideal formula variations that make Victor Starch "custom-made" for individual requirements.

For additional information, write for Keever Data Sheet 170.

THE KEEVER STARCH COMPANY

538 East Town Street, Columbus 15, Ohio

Processors of grain products for industry since 1898

METASOL

SLIME CONTROL ENGINEERING

Scientific slime control methods now available

METASOL *microbiologist prepares petri dish test to determine micro-organism count of white water.*

New METASOL Krylate Spray keeps surfaces slime-free for extended periods

A new METASOL slimicide product, METASOL Krylate Spray, is another weapon in furthering the effectiveness of a slime control program. When applied to wood, ceramic, concrete and steel surfaces, METASOL Krylate forms a slime-resistant, water-resistant film which keeps these surfaces slime-free for months.

METASOL Krylate is packed in pressurized aerosol containers and sprayed on the desired surface by means of a spray nozzle. Its principal use is on suction boxes, doctor blades and similar inaccessible areas which cannot be cleaned regularly.

Used in conjunction with METASOL Slimicide, METASOL Krylate provides an effective and lethal one-two punch to slime-producing organisms.

A word about METASOL Slimicides

METASOL Slimicides were developed after 7 years of intensive testing and evaluation of almost 2,000 slimicidal products. Chemically, they have a unique di-phenylmercuric ammonium propionate structure. Their special advantages are: high, fast solubility in water; minimum deactivation; rapid initial kill and sustained killing action. They also do not allow resistant organisms to form. METASOL Slimicides will not impart color or odors to the paper. Available in either solid or liquid form, METASOL Slimicides have produced outstanding results in effective slime prevention.

Microbiological and chemical analyses show the way

Microbiological slime is a constant, persistent enemy to paper mills. In fact, many mill men are resigned to the fact that they will always have a slime condition and that the only way to achieve reasonable control is by constant trial-and-error experimentations with different slimicides. While understandable, this attitude can be costly and uneconomical when measured in terms of slimicide cost, quality variations and down time.

Importance of Scientific Analysis

The point is, effective slime control is possible if the problem is approached with scientific exactness. The source and type of infection must be properly identified. Then a formal program must be developed which details proper slimicide treatment and application, insures proper training of personnel in slime control methods and which insures systematic follow-through and inspection.

Microbiological Analysis

The initial analysis must be conducted at the mill under trained microbiologists, using specialized equipment and scientific methods. Because most mills do not have such facilities, the METASOL DIVISION maintains a field service of microbiologist teams equipped with portable laboratory equipment. The services of these teams are available to mills without cost. It is part of our established policy to provide paper mills with the finest in slime control products and techniques.

Programming Success

METASOL's slime control programming has been uniformly successful. In mills where it has been installed, machines are cleaner, periods between boil-outs have been lengthened, paper quality is higher and slimicide costs have been kept under control. For further information on this service, write or call us.

METASOL DIVISION, Metalsalts Corporation, 200 Wagaraw Rd., Hawthorne, N. J.
METASOL Slime Control Products are produced by Metalsalts Corporation, Hawthorne, N. J.

R/M CONVEYOR BELTS GIVE YOU "More Use Per Dollar"

BECAUSE THEY ARE ENGINEERED FOR YOUR JOB...AND BALANCED-BUILT FOR LONGER LIFE

Homoflex Log Conveyor Belt absorbs the shock of logs rolling from debarker.

Handling chips or newly debarked logs—R/M conveyor belts are engineered to stand up where ordinary conveyor belts tear, puncture or fail due to fastener pull out. Ray-Man Conveyor Belt, for example, trains naturally, troughs easily —to handle *fuller, heavier* loads even where small pulleys are used. Compensated, balanced construction prolongs belt life. Ray-Man requires no breaker strip, offers exceptional fastener and splice holding ability under extreme operating conditions.

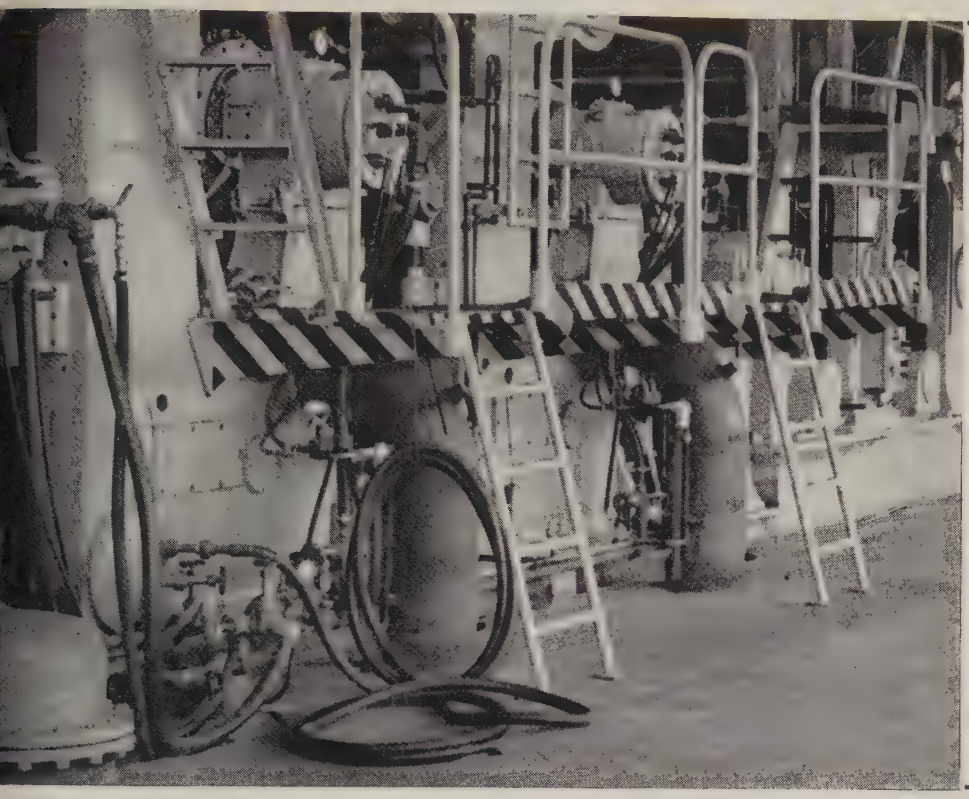
Like all R/M heavy duty conveyor belts, Ray-Man is mildew-proof and moisture resistant . . . can be made oil-proof when used under chippers. R/M's exclusive "XDC" Covers add extra protection against wear, tear, cuts and abrasions never before possible. Ask an R/M representative to show you the advantages of Ray-Man and other R/M conveyor belts . . . and write for newest conveyor belt bulletins.

ENGINEERED RUBBER PRODUCTS ... MORE USE PER DOLLAR

RAYBESTOS-MANHATTAN, INC.

MANHATTAN RUBBER DIVISION, PASSAIC, NEW JERSEY

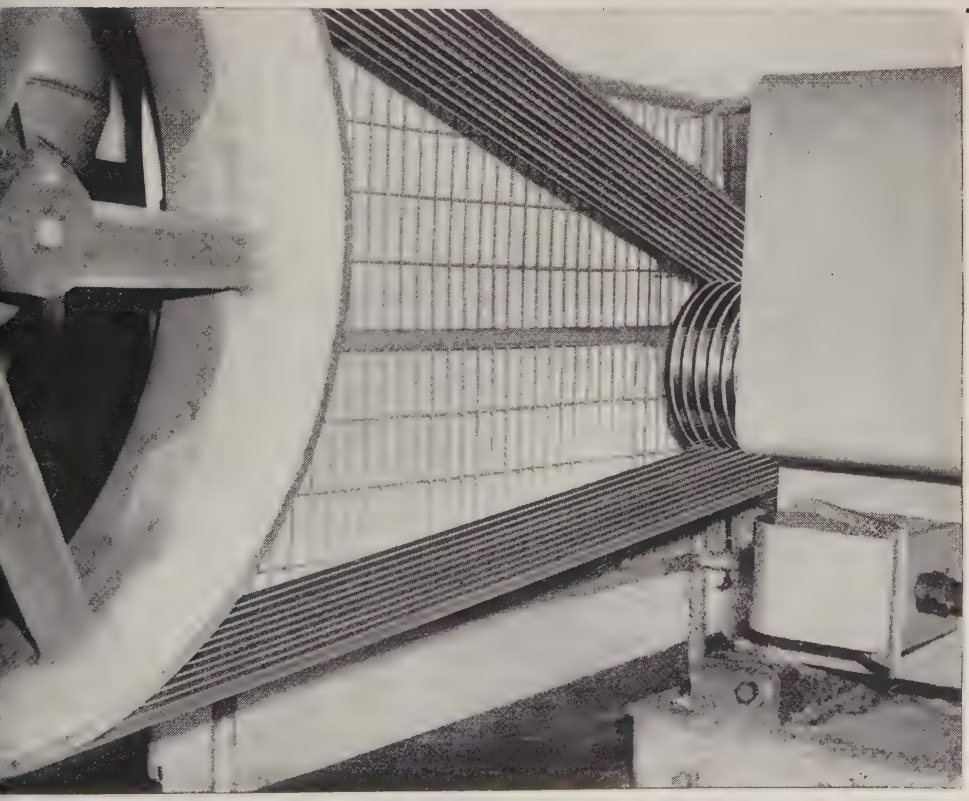
HOMOFLEX PAPER MILL HOSE IS MORE FLEXIBLE, WEIGHS LESS THAN ANY HOSE FOR EQUAL PRESSURE



- SUPER-STRONG
- PRECISION BUILT
- NO PRE-SET TWIST—WILL NOT KINK
- INSEPARABLE TUBE-TO-COVER BOND
- UNIFORM INSIDE AND OUTSIDE DIAMETERS
- EASIER, SAFER COUPLING
- AVAILABLE WITH BUILT-IN TAPERED RUBBER NOZZLE
- DISTINCTIVE GREEN COLOR
- "MORE USE PER DOLLAR"

Strong, lightweight, and "flexible as a rope"—Homoflex is the easiest handling water hose made for paper mill use and lasts longer. Ask about other types of R/M rubber hose for your job applications. Write for Bulletins M620 and M694.

CONVERT TO R/M POLY-V® DRIVE FOR MORE POWER IN LESS SPACE...with RELIABILITY!



- SINGLE UNIT DESIGN
- ELIMINATES "MATCHING" PROBLEMS
- MAINTAINS GROOVE SHAPE
- CONSTANT PITCH AND SPEED RATIOS
- LESS WEAR ON BELT AND SHEAVES
- COMPLETE CONTACT-PRESSURE

Just two Poly-V belt cross sections meet every heavy duty paper machine transmission requirement. On the Nash Pump drive shown, a single Poly-V Belt replaced 22 troublesome V-Belts.

R/M Poly-V Drive is the smoothest running, coolest running—*longest wearing* drive you can install. Write for Poly-V* Drive Bulletin M141.

*Poly-V is patented by Raybestos-Manhattan, Inc.

11 POINTS OF SUPERIORITY

Tension bar for balanced machine stresses
Kingsbury thrust bearings (for refiners with 600 hp and above)
High production with efficient utilization of power
Peripheral control ring for greater refining control
Parallel plate operation through three-point suspension tramming
Uniform feed
Precision manufacture, with sensitive, close tolerance adjustments
Minimum maintenance
Rugged vibration-free construction
Swinghead design for simplified plate changing
Integral oiling system

THE WORLD-FAMOUS 36-2 "SPROUT"

single disc precision pulp refiner

The 36-2 Sprout refiner is the most efficient disc refiner in quantity of output and in quality of refined pulp per horsepower input. It is preferred throughout the industry for every pulping application where rubbing and brushing action, without cutting, is required. Sprout-Waldron units lead the field in the refining of semichemical pulp, cold caustic pulp, screen rejects, wastepaper stock; brown stock and hot stock refining of high yield kraft pulp; refining of bagasse, flax and straw pulping; as well as preparation of insulation and hardboard fiber. For the latest details on the 36-2 Sprout, request Bulletin 96-B.

SW

SPROUT, WALDRON & CO., INC.

MUNCY, PENNSYLVANIA, U. S. A.

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E/200

THIS SLOW-MOTION ATLANTIC TESTING MACHINE

CAN IMPROVE YOUR HIGH-SPEED PACKAGING OPERATIONS

At the rate that paraffin coated boxes and cartons slide from stack to packaging machine, even a split second of delay can start a costly, time-consuming chain reaction all along the line. To insure continuous and profitable operation, the waxed surfaces must slip freely across each other during their instant of contact.

Shown above is an exclusive testing device used by Atlantic research technicians to determine slip properties of paraffin waxes. Basically, the test consists of measuring the force necessary to slide one paraffin coated sample along another. Slip is reported in terms of the coefficient of friction, with low coefficients as the objective. The slip characteristics of a proposed paraffin coating can thus be determined before production gets underway.

This Slip Test Machine is typical of the testing equipment used in the Atlantic Research Department. Others include our exclusive Imflex Tester for determining impact resistance and flexibility . . . the Seal Strength Tester which measures the force necessary to separate wax laminations and seals . . . the Beam Test, to establish durability of waxed corrugated stock . . . and tests for gloss, tensile strength and resistance to grease.

Your experienced Atlantic Sales Engineer will be happy to give you complete information on how our paraffin research facilities can be of service to you. In many cases he can supply on-the-spot assistance. When more specialized information is required, he has the full and prompt assistance of the Atlantic Research and Development Department.

ATLANTIC

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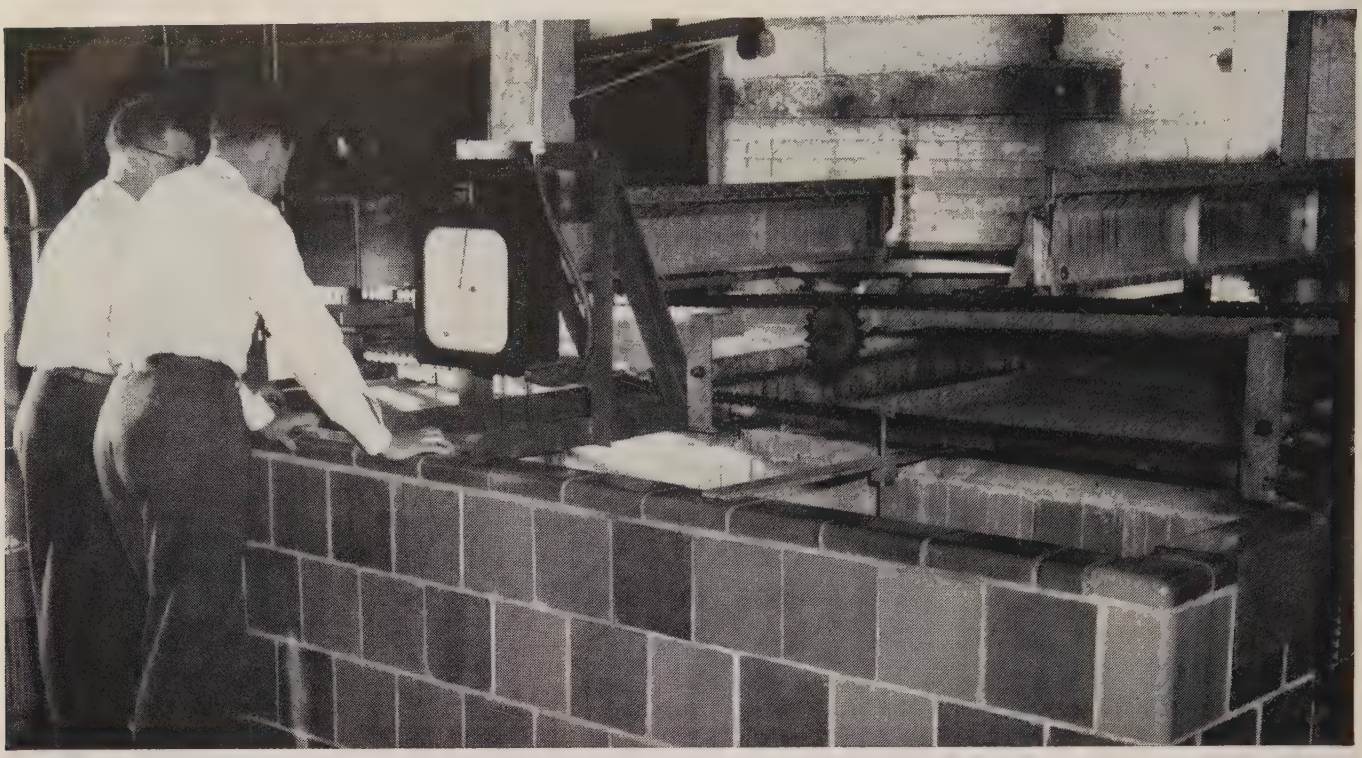
FLUIDICS* AT WORK



Checking clarified effluent of the Permutit Colloidair Separator at the Homasote Company

How to side-step a public health hazard . . . and step into big new savings

Maybe you have a problem similar to the one that confronted the Homasote Company, Trenton, N. J.

They make high-density wood fiber insulation board. The process *could* create a waste disposal problem and impair the company's good community relations.

The answer found by Homasote turned out to be more than just a waste treatment system. It is also a valuable way to save money, through reclaimed product and water.

The Permutit Colloidair Separator is behind this accomplishment.

Saves product. White water feeds into the Colloidair, where a "bubbling-out" process raises the fibers to the surface. These fibers are scraped off and reclaimed.

Saves water. No water is wasted in this closed-circuit operation. Colloidair clarifies it for Homasote's re-use in pump glands, stuffing box seals, and for general cleanup.

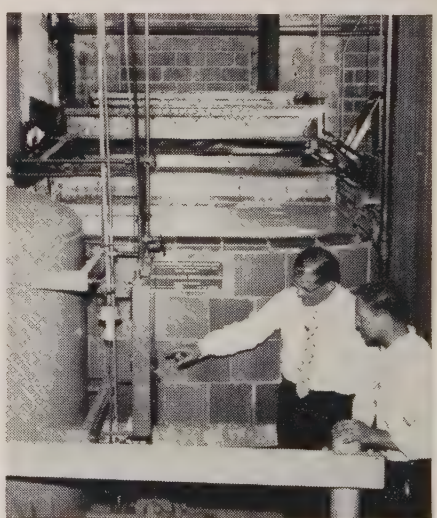
Saves heat. The reclaimed water holds most of its heat during the clarifying process. This saves the expense of reheating for re-use.

Easy to use. Colloidair works almost by itself. The operator does little more than periodically charge chemical tanks.

Homasote is getting these benefits today . . . when would YOU like to start?

We will be glad to run lab and/or pilot plant tests to show just what the Permutit Colloidair Separator can do with your white waters and/or waste waters.

Save your public relations . . . and your money. Get more information on Colloidair by writing our Permutit Division, Dept. TA-90, 50 West 44th Street, New York 36, New York.



Observing Colloidair's chemical feed at Homasote

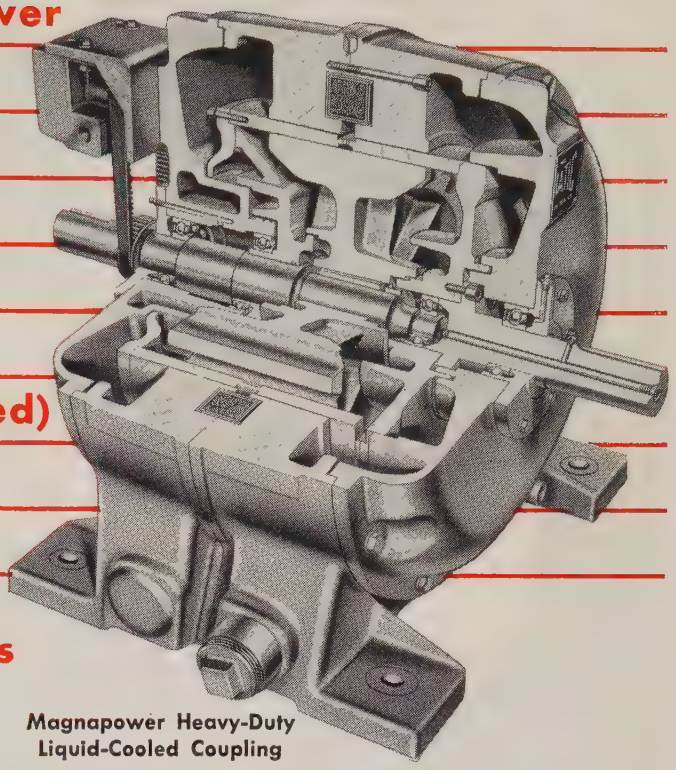
*FLUIDICS is a new Pfaudler Permutit program that provides a modern, imaginative approach for handling and processing liquids and gases more profitably.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . . the science of fluid processes

10 good reasons for choosing Dynamatic Eddy-Current Speed Control Equipment

1 Adjustable speed from AC power
2 Accurate speed control
3 Wide speed range
4 Rapid response
5 Low power loss
6 Simplified construction
7 Remote control (when desired)
8 Quiet, efficient operation
9 Low maintenance cost
10 No commutators, rings, brushes, or rotating coils



Magnapower Heavy-Duty Liquid-Cooled Coupling

Using standard alternating current as a power source, Dynamatic Eddy-Current Couplings and Drives are the answer to practically all stepless adjustable speed requirements.

A wide range of standard and special control features may be obtained from electronic or transistorized magnetic amplifier control systems. The addition of an eddy-current brake to standard couplings or drives provides smooth, cushioned stops and controlled deceleration.

Dynamatic Eddy-Current Equipment is available in sizes from ¼ hp Ajusto-Spede Drives to heavy-duty Magnapower Couplings rated up to 20,000 hp—and larger.

Place your speed control problems in the hands of experts. Our representatives, located in all principal cities, are fully qualified to discuss your speed control problems and suggest Dynamatic Equipment that will do the best job for you. Call Dynamatic today—there is no obligation.

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ORIGINATOR AND LEADING PRODUCER OF EDDY-CURRENT SPEED CONTROL EQUIPMENT

May we Send You Illustrated Literature Describing Dynamatic Eddy-Current Equipment

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DYNAMATIC DIVISION
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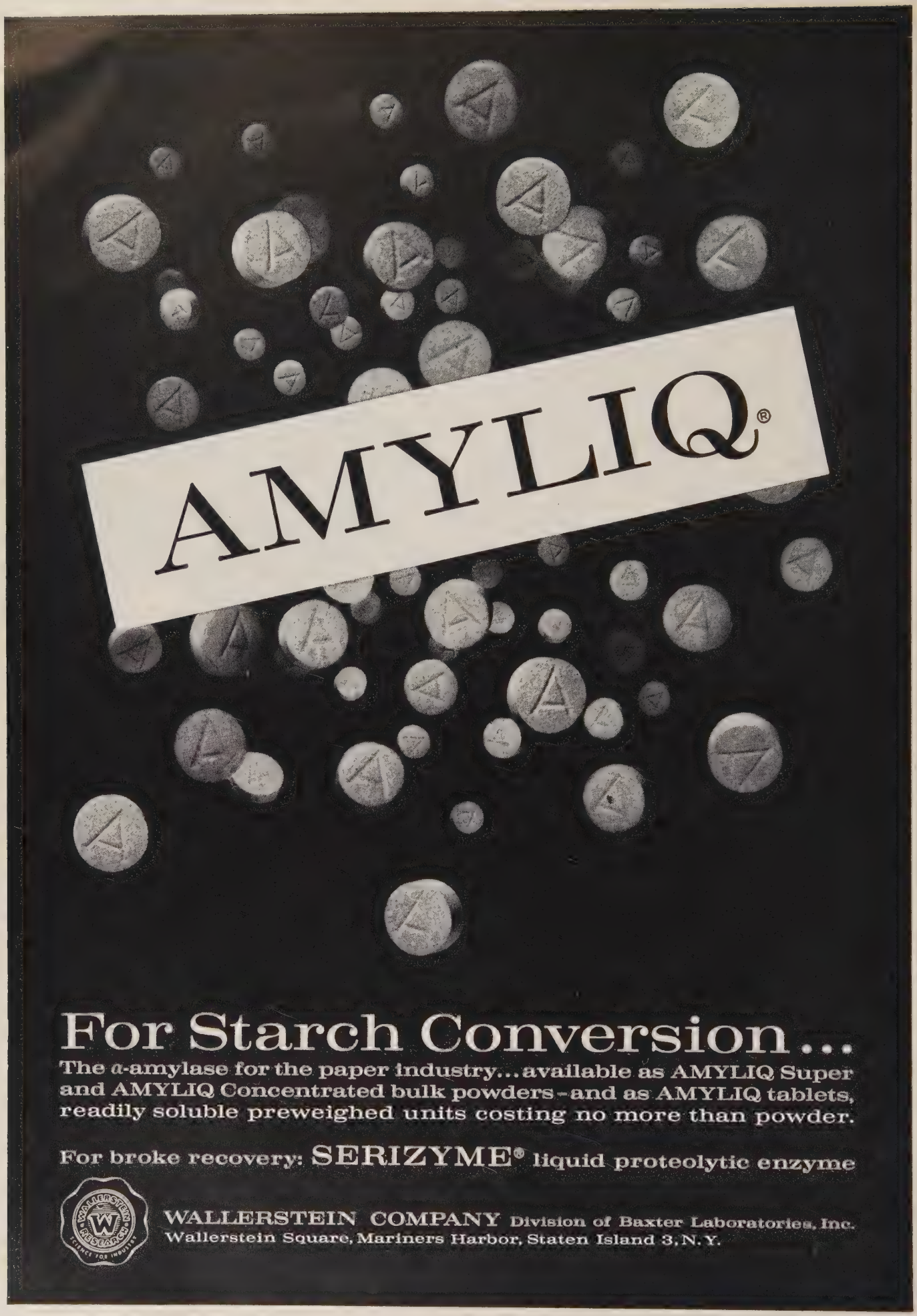

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For broke recovery: SERIZYME® liquid proteolytic enzyme

WALLERSTEIN COMPANY Division of Baxter Laboratories, Inc.
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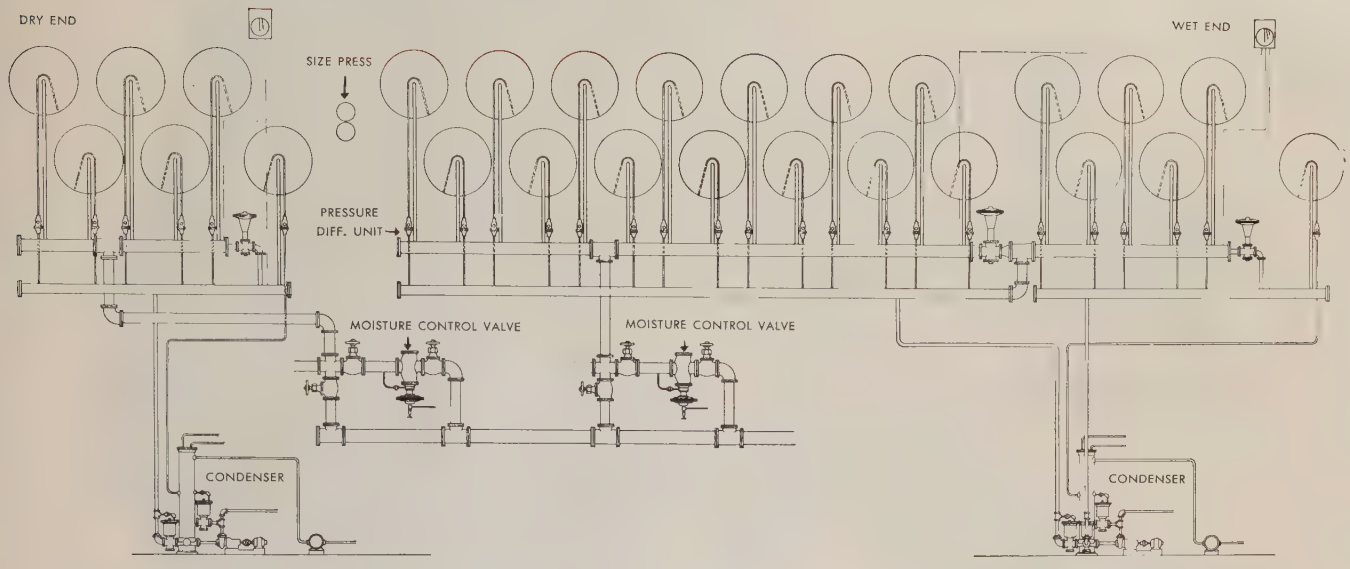
ALL Steamed Up OVER STEAM COSTS?



THEN THESE

FACTS WILL INTEREST YOU:

- The Appleton Dryer Drainage system dries paper at *lowest* possible steam cost.
- Steam is discharged from only the *first wet end dryer,* assuring maximum steam economy.
- Blow-through flash system uses no traps or flash tanks, provides natural descending heat curve toward wet end.
- Steam control valves *automatically* shut off during paper break, reopen when sheet is taken over machine preventing wet or over-dried paper.
- Exclusive, patented pressure differential units maintain proper differentials *under either pressure or vacuum conditions* guaranteeing removal of condensate and air.
- The system is versatile, now being used in mills running condenser tissue, towelling, glassine, writing papers, board and other grades.
- Installation is simple, in many instances existing piping may be used and installation made over weekend shut-down.
- *Complete details will be sent upon request. Please state if any special problems are involved. We will reply promptly, fully and without obligation.*

APPLETON MACHINE COMPANY
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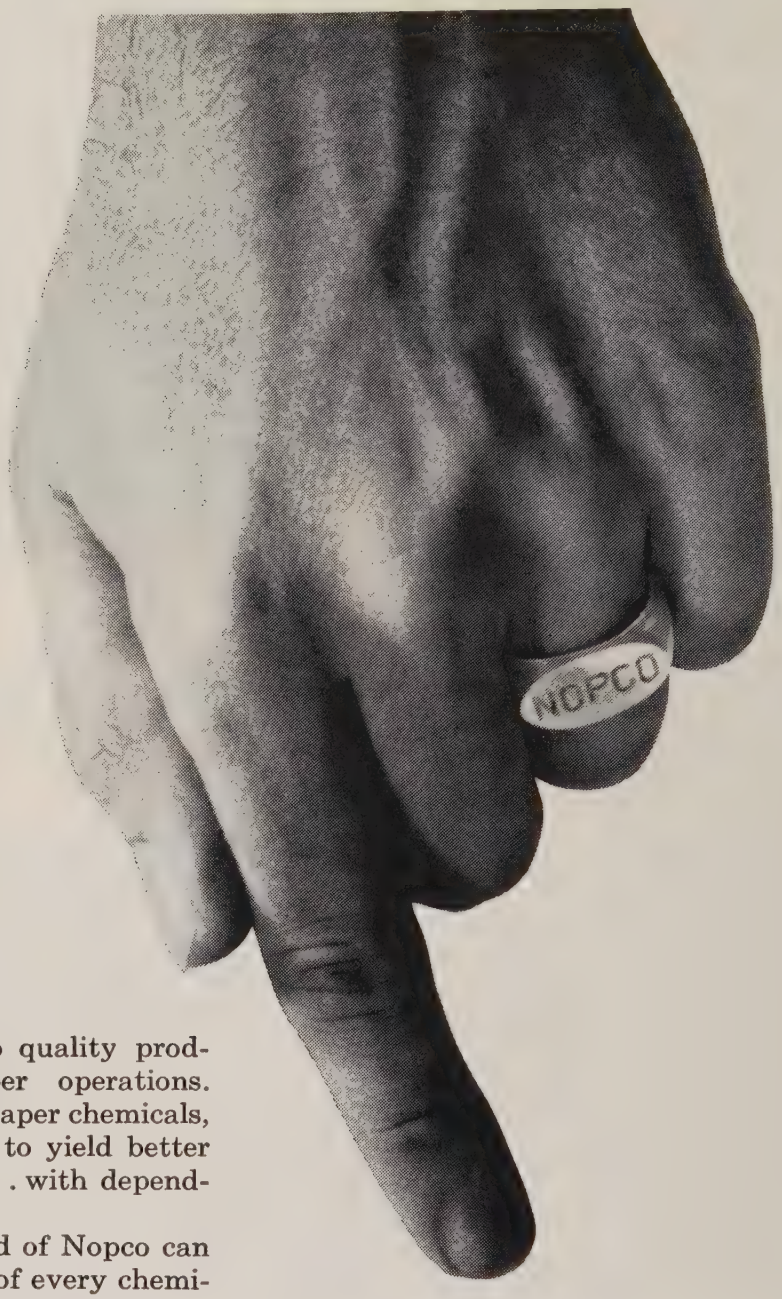

NOPCO POINTS THE WAY

Nopco points the way to quality products in pulp and paper operations. Nopco offers a full line of paper chemicals, each specifically designed to yield better products . . . every time . . . with dependability you can count on.

Perhaps the skilled hand of Nopco can go to work for you. Back of every chemical made by Nopco for the paper industry stands Nopco Technical Service—an experienced staff ready to assist with laboratory data and recommendations based upon your specific requirements.

DEFOAMERS	FELT WASHING DETERGENTS
WAX SIZES	CALENDER STACK LUBRICANTS
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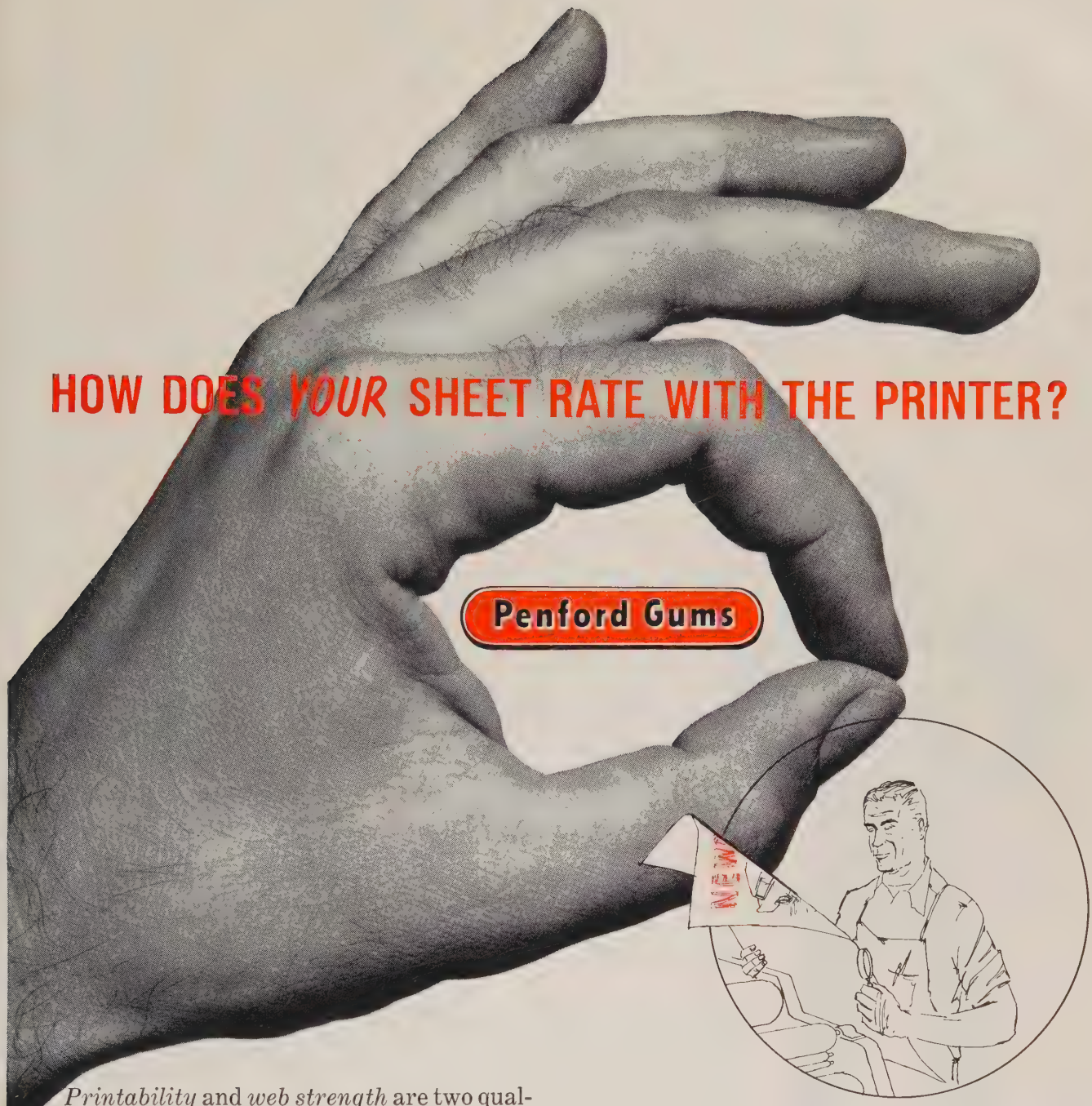
NOPCO®

Plants: Harrison, N.J. • Richmond, Calif. • Cedartown, Ga. • London, Canada

HOW DOES *YOUR* SHEET RATE WITH THE PRINTER?



Printability and *web strength* are two qualities he looks for—and Penford Gum can help you build them into your sheet. Papermakers up and down the land have learned that they can get higher quality production using Penford Gum because of its unique filming properties and high strength.

P & F helps in other ways too. It offers a variety of starch products that can be tailored to your particular paper-making needs—and also the technical know-how of its Service Department. Our Technical Service Representative can simply demonstrate the advantages of Penford products, or he will be glad to apply his experience to your whole paper-making process.

To upgrade your sheet, get in touch with Penick & Ford today!

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Yes, when you think about it, bright white space is what EDGAR PAPER CLAYS are—and shipped to you in the most convenient form—bag, bulk or slurry—rail or truck.

Step #1 in the preparation of this "bright white space" is selective mining of prime kaolin clay . . . Step #2 is water washing and fractionation with controlled viscosity and particle size to each papermaker's specification . . . Step #3—drying and large volume storage for prompt deliveries.

And—over 1,000 control tests per day to assure you highest quality Edgar clays.

Help yourself to "bright white space" in your papers.
Call M&C for ample samples, complete technical service.

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A "Special Detergent" for continuous washing of pickup felts

IGEPAL® CO-630

is economical, easy to apply...lengthens felt life

Because of its truly nonionic nature, Igepal CO-630 does not form insoluble precipitates with calcium and magnesium, as does soap, or anionic based detergents. This nonionic detergent is compatible with alkaline salts, acids and commonly used solvents, but contains no harmful alkalis to weaken felt.

Paper machine wet-end felts can be washed with Igepal CO-630 solutions in the usual felt conditioning units, either continuously or intermittently while running; there is a minimum of foaming action. Igepal improves drainage, is positively non-shrinking. Complete technical information supplied on request. Simply write–

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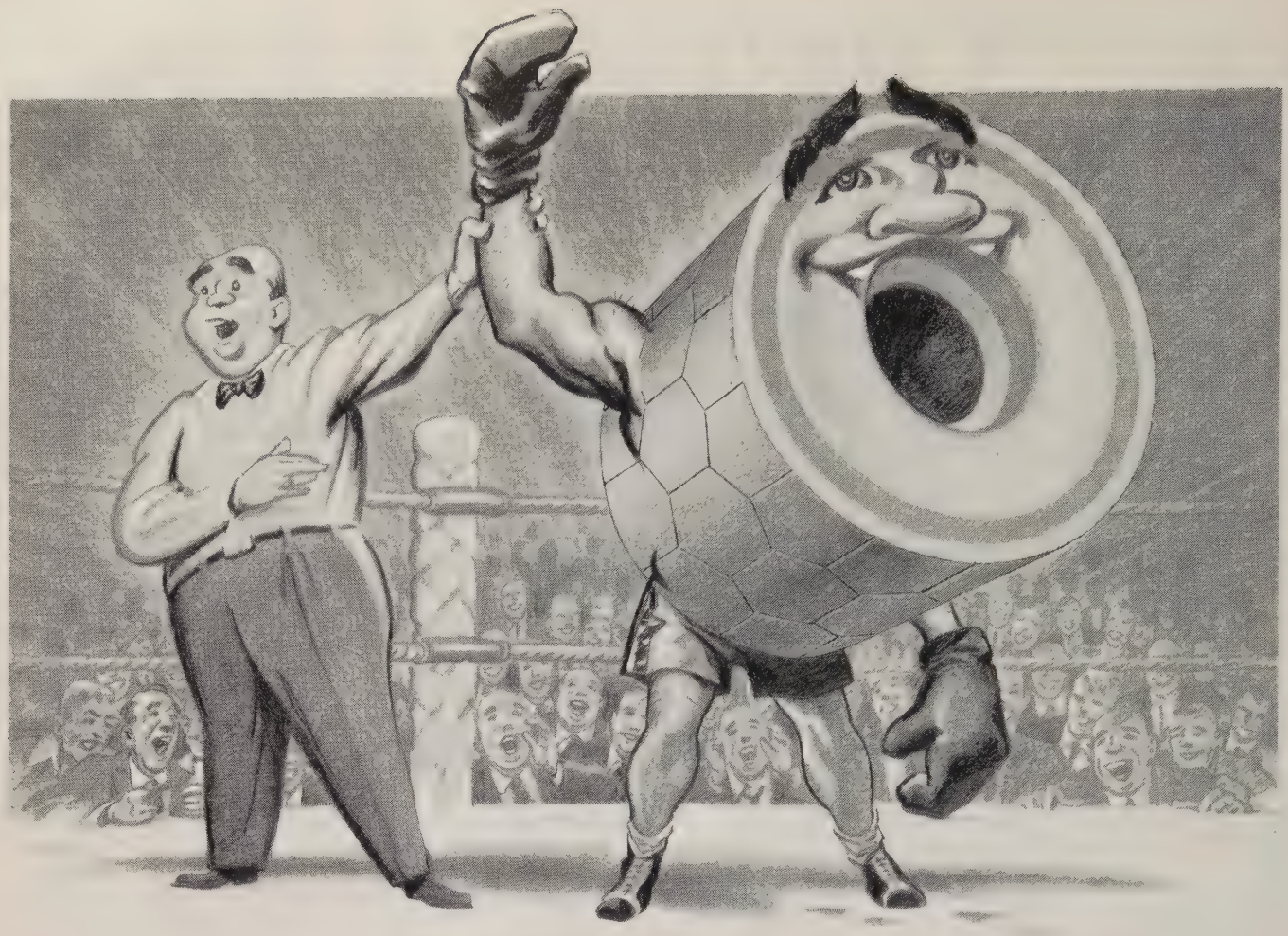
Igepal CO-630, manufactured by General Aniline & Film Corp., is sold outside the United States and Canada under the tradename Antarox CO-630 by distributors all over the world.



The WINNAH...and CHAMPION *as always*

The unchallenged reputation of Norton pulpstones for being able to "stand up and take it" — to stay in profitable production year after year — is supported by cold, hard facts.

Statistics show that since 1926, when Norton produced the first successful pulpstone, many of the thousands of Norton pulpstones used by paper mills in all parts of the world have had an average productive life of more than 30,720 hours. Most have produced an average of more than $5,000,000 worth of pulp. That's championship performance in any language!

Today, as in the past, each Norton pulpstone is carefully engineered to meet the special requirements of each individual mill. To get championship pulpstone performance in *your* mill, consult the Norton pulpstone engineer in your territory. He is qualified by experience to study your mill and to recommend just the right Norton pulpstone for your type of wood, your type of grinder and the type of pulp you want to produce.

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NORTON PULPSTONES — *the world's standard for mechanical pulp*

75 years of . . . Making better products . . . to make your products better

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — BEHR-MANNING DIVISION: Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

TEST SHEET

TEAR OFF THIS SHEET AND TEST IT FOR WET STRENGTH

SOAK IT!

THEN PUT IT THROUGH THE WET TENSILE TEST— NOTE HOW IT MAINTAINS A HIGH PERCENTAGE OF WET STRENGTH! TURN OVER TO LEARN HOW THIS SHEET GOT ITS WET STRENGTH.

CYANAMID

THIS SHEET PRODUCED BY **CYANAMID'S HE* PROCESS** IN CONJUNCTION WITH

MELOSTRENGTH® RESIN

Cyanamid's exclusive **HE** process, using **MELOSTRENGTH** Wet-Strength Resin, provides remarkable wet-strength results. If you're **economy** minded, you would appreciate using 30% to 50% less wet-strength resin while still maintaining specifications. If you're after **greater strength,** you can achieve papers with wet-strength never before attainable, using the same amount of resin required for ordinary strength.

MELOSTRENGTH gives you: 1. **Strong paper** even when soaked. 2. **Permanence of strength** even under storag conditions of high humidity. 3. **Good resistance** to mo chemicals and acids. 4. **It is non-linting**—wipes clea without shedding.

MELOSTRENGTH Wet-Strength Resin can be applie to paper of practically every weight and grade. It especially effective in the manufacture of grocery bag tissues, napkins, towels, laundry tags and auto se covers. For full information, contact us.

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Wet or Dry . . It's Stronger

CYANAMID

PUT THE *SQUEEZE* ON
WHERE IT HELPS...

IN LIQUOR REMOVAL

Send me facts on:

- ☐ Removing spent liquor
  - ☐ From N.S.S.C. cooked chips
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Other Applications:

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  - ☐ For savings in refining costs
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Probably the most important is their consistent uniformity. You can depend that each felt will meet your exact specifications for finish, drainage and strength, because we maintain the most precise control over every step of production from raw wool processing through final inspection.

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WATERBURY FELTS

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photo courtesy of Thilmany Pulp & Paper Co., Kaukauna, Wisconsin

ACRI-FLO 151 helps wrap out the weather

For years paper manufacturers have searched for an economical, non-staining protective kraft that would wrap out the weather. Now that search has ended! With Acri-flo 151 it is possible to produce such a wrap . . . a high-impact, duplex kraft from less costly sheets. This is only one of the many ways Acri-flo has helped the paper industry produce better products at lower cost. A letter from you today will bring you proof of how Acri-flo can help improve your paper products!

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Chemicals for the rubber, paint, paper, textile, plastics and other industries: **GENTRO SBR** *rubber* **GENTRO-JET** *black masterbatch* • **GEN-FLO** *styrene-butadiene latices* • **GEN-TAC** *vinyl pyridine latex* **GENTHANE** *polyurethane elastomer* • **ACRI-FLO** *styrene-acrylic latices* • **VYGEN PVC** *resins and compounds* • **KURE-BLEND** TMTD *masterbatch* • **KO-BLEND** *insoluble sulfur masterbatch*

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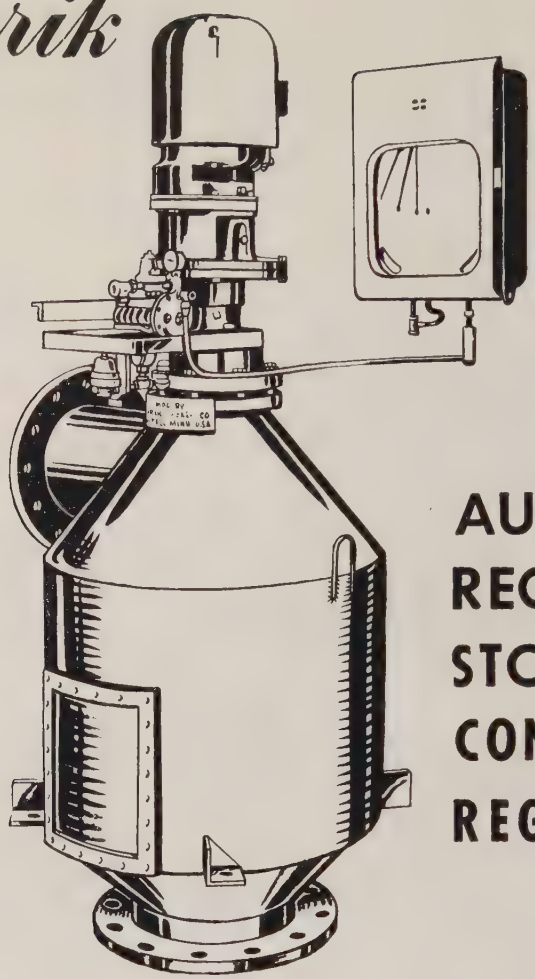

AUTOMATIC RECORDING STOCK CONSISTENCY REGULATORS

Guaranteed to hold consistencies within limits of plus or minus .1%, many DeZurik Consistency Regulators, installed directly ahead of paper machines, are holding consistencies to plus or minus .02%! Accuracy like this can be yours on wide range of tonnages and installations.

DeZurik Consistency Regulators are available in three basic types: Pipe Line type (illustrated), Pan type and Open type. Write for details.

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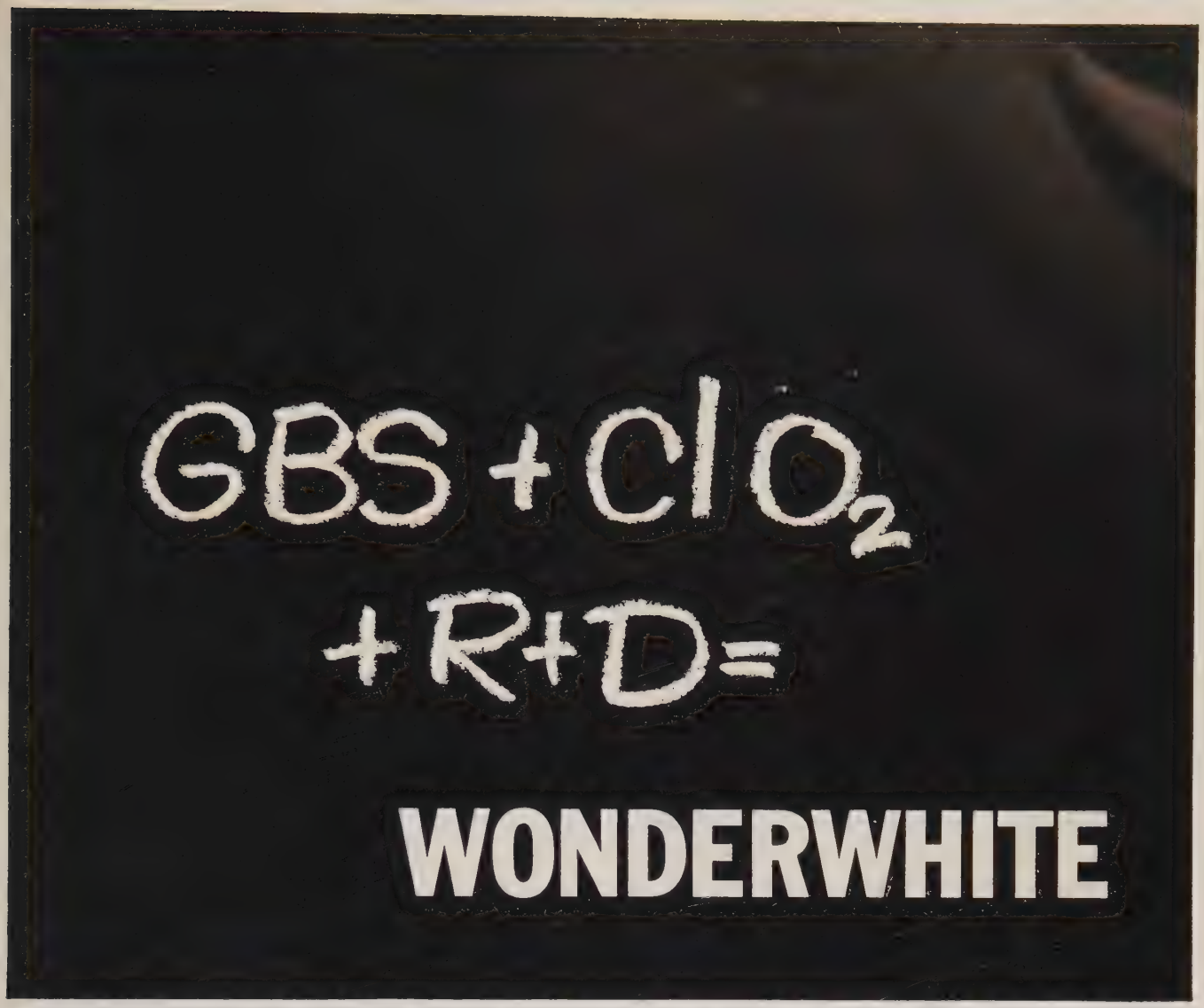

Gaspesia Bleached Sulphite *plus* Chlorine Dioxide *plus* Research and Development equal WONDERWHITE

You have been hearing a great deal about this new Gaspesia Bleached Sulphite Pulp with Chlorine Dioxide which is now coming from our mill in Quebec. We call it WONDERWHITE because performance records are topping even our laboratories' predictions.

Our Research and Development give WONDERWHITE a strength surpassing that of any other sulphite now on the market. At the same time, WONDERWHITE retains the excellent formation plus printing characteristics and excellent opacity of a good spruce sulphite.

Another plus: Chlorine Dioxide gives WONDERWHITE unsurpassed brightness and guarantees the highest degree of cleanliness.

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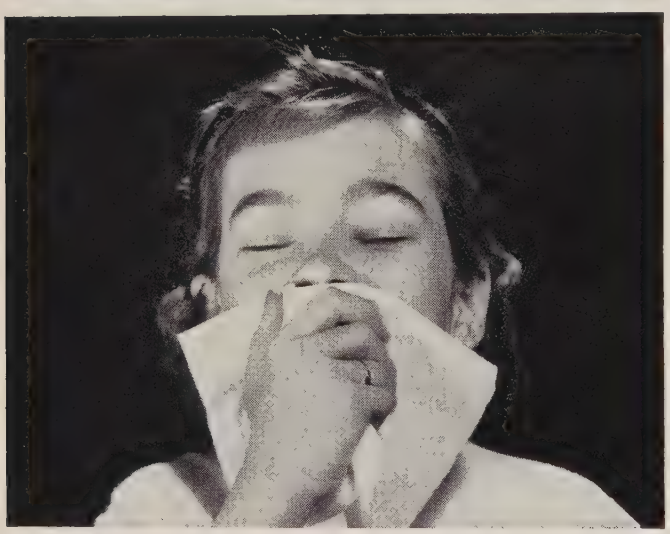

Need wet strength? . . . You'll find that one of the Rohm & Haas UFORMITE resins will suit your processing requirements and the end-use application—be it toweling, napkins, bag paper, butchers' wrap, paperboard, or a specialty item. Note the advantages exhibited by all three resins: 1) excellent storage stability, 2) immunity to sulfate ions, 3) ease of handling (no acid pretreatment or aging required), 4) easy broke recovery.

The properties of the individual resins are these: UFORMITE 700—high off-the-machine wet strength without attendant broke recovery problems. UFORMITE 711—efficient all-round performance at moderate cost. UFORMITE 467—maximum economy in unbleached grades of paper.

Write for our 24-page booklet, UFORMITE *Resins for Wet Strength Paper.*

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Chemicals for Industry

ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

UFORMITE

NEW AUTOMATIC PASTE ROSIN SIZE EMULSIFIER

for continuous paste rosin emulsion preparation

Connect this complete packaged size emulsifier to your plant steam, paste rosin, and water lines, and begin immediately to enjoy the benefits of continuous size preparation. Developed jointly by Milton Roy Company and Monsanto Chemical Company to meet your specific needs, the new, compact emulsifier brings real economy and dependability to automatic, trouble-free size preparation for the first time.

High solids content paste (70 to 77%) is fed directly into a recirculating heat exchanger from which it is accurately metered to the first mixing stage. Water heated within the unit dilutes the heated rosin paste to a primary 10% solids content emulsion. The primary emulsion is then further diluted with cold water either in the unit or at the storage tank to arrive at a final size emulsion of from 2 to 6% solids content, as desired.

Unique features built right into the Milton Roy emulsifier assure a dependable and accurate flow of size at just the right temperature and consistency to meet the requirements of your paper machines. For example, a closed heat exchanger recirculating paste rosin positively eliminates foaming and oxidation problems. Preparation time has been cut to an absolute minimum. Once the controls are set, the unit operates continuously without supervision.

Complete details on the Milton Roy paste rosin size emulsifier are in Bulletin 959, available on request to Milton Roy Company, 1300 Mermaid Lane, Philadelphia 18, Pa.

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Controlled Volume Pumps • Quantichem Analyzers
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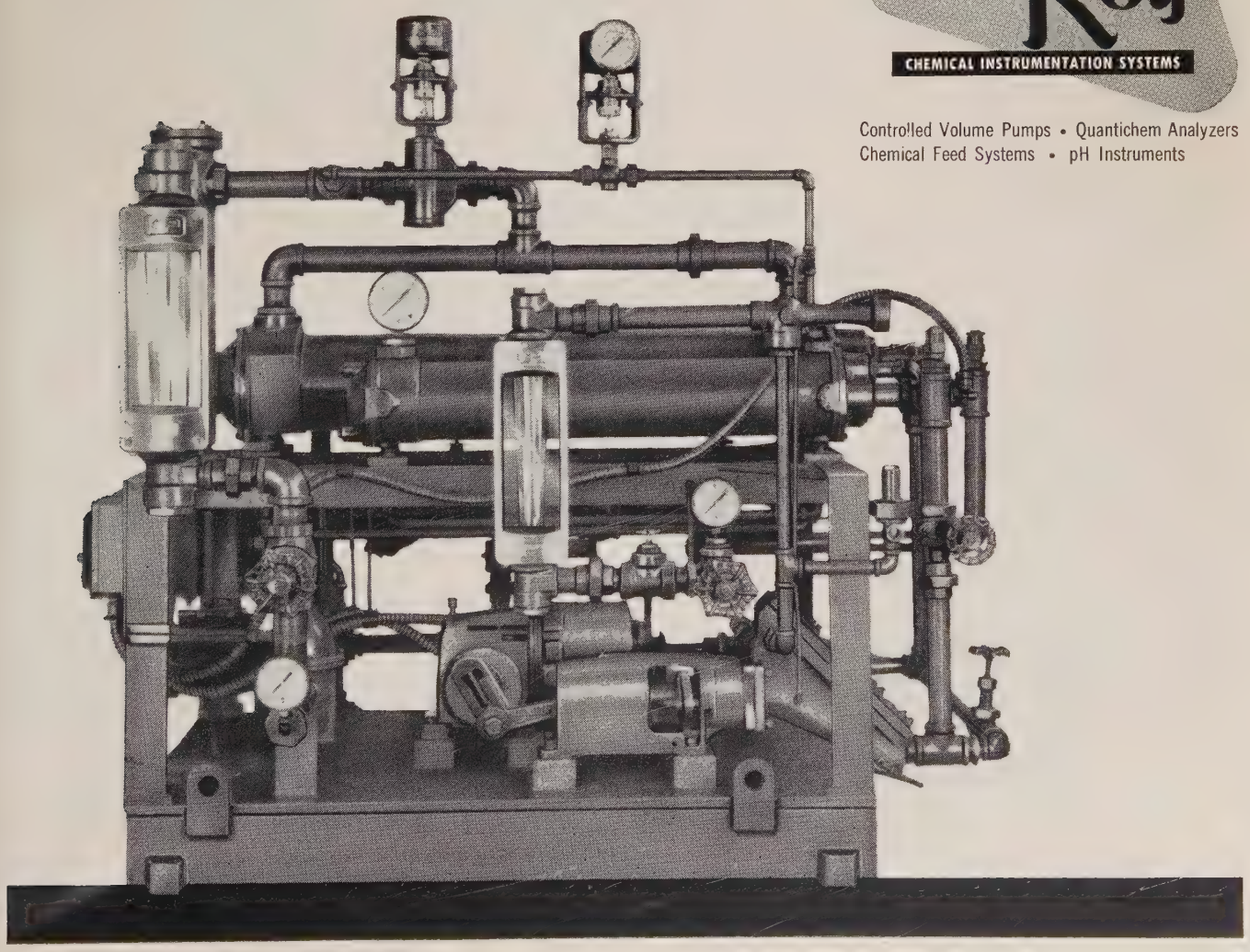

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- ABUNDANT STORAGE
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- VAST NATURAL SOURCE OF RAW MATERIAL
- ALL COMMITMENTS SCRUPULOUSLY MET
- FRIENDLY, HELPFUL ATTENTION TO INDIVIDUAL NEEDS
- PROMPT, AUTHORITATIVE ANSWER TO EVERY INQUIRY

However you view your needs, you will find in West End a unique coordination of specialized services, extensive production facilities and product excellence essential to the prompt, efficient handling of individual requirements.

All commitments scrupulously met

1925 1960

For over 35 years, West End has unconditionally fulfilled every commitment it has ever made. Expanding along with the chemical processing industry, West End meets the ever-increasing normal and unanticipated requirements of our customers with equal ease and dispatch.

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WEST END CHEMICAL COMPANY • DIVISION OF STAUFFER CHEMICAL COMPANY

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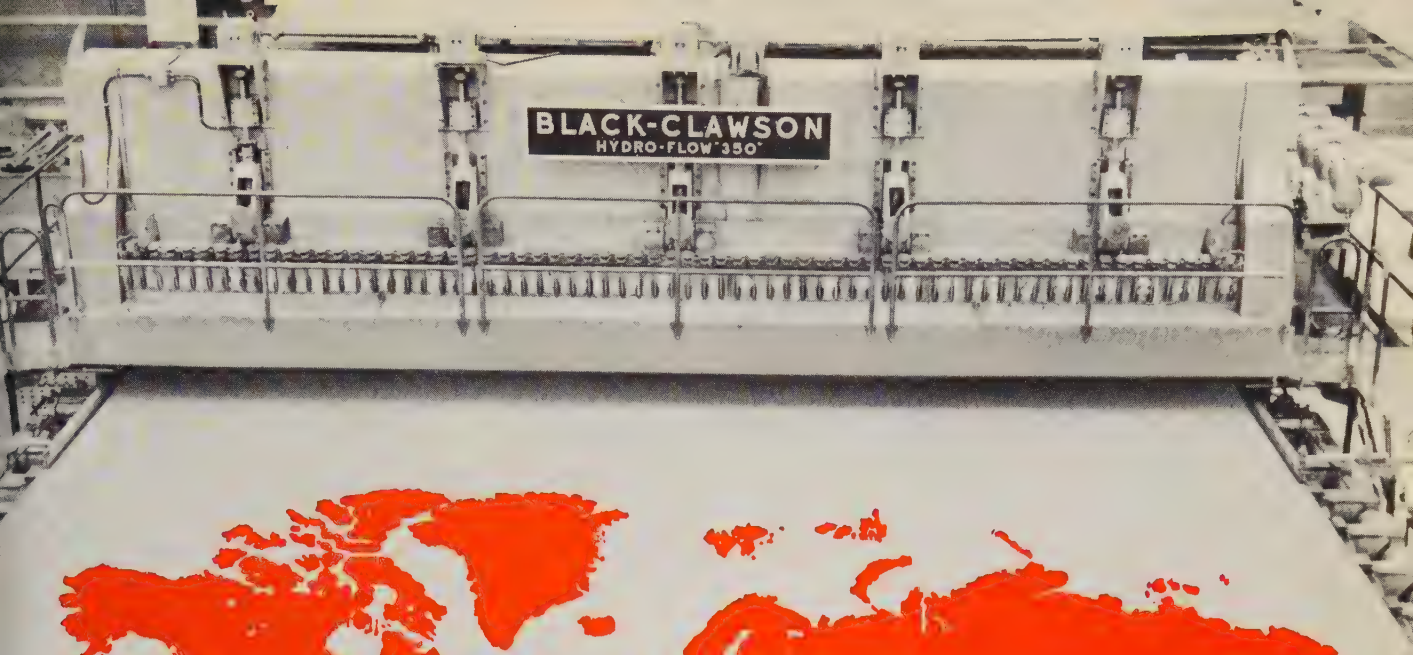

BLACK-CLAWSON 2000 FPM
NEWSPRINT MACHINE

Wherever Paper is Made . . .
Black-Clawson is There

The scope of Black-Clawson service to the world-wide pulp and paper industry continues to multiply in two ways.

. . . in the growth of international trade areas where Black-Clawson engineering, manufacturing and sales-service facilities are active.

. . . in the creation of new machinery and technical developments for every phase of pulp and paper production from pulp mill to converting plant.

Black-Clawson serves 54 papermaking countries.

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SHARTLE DIVISION STOCK PREPARATION

PAPER MACHINE DIVISION PAPER & BOARD MACHINES

DILTS DIVISION CONVERTING MACHINERY

THE BLACK-CLAWSON COMPANY

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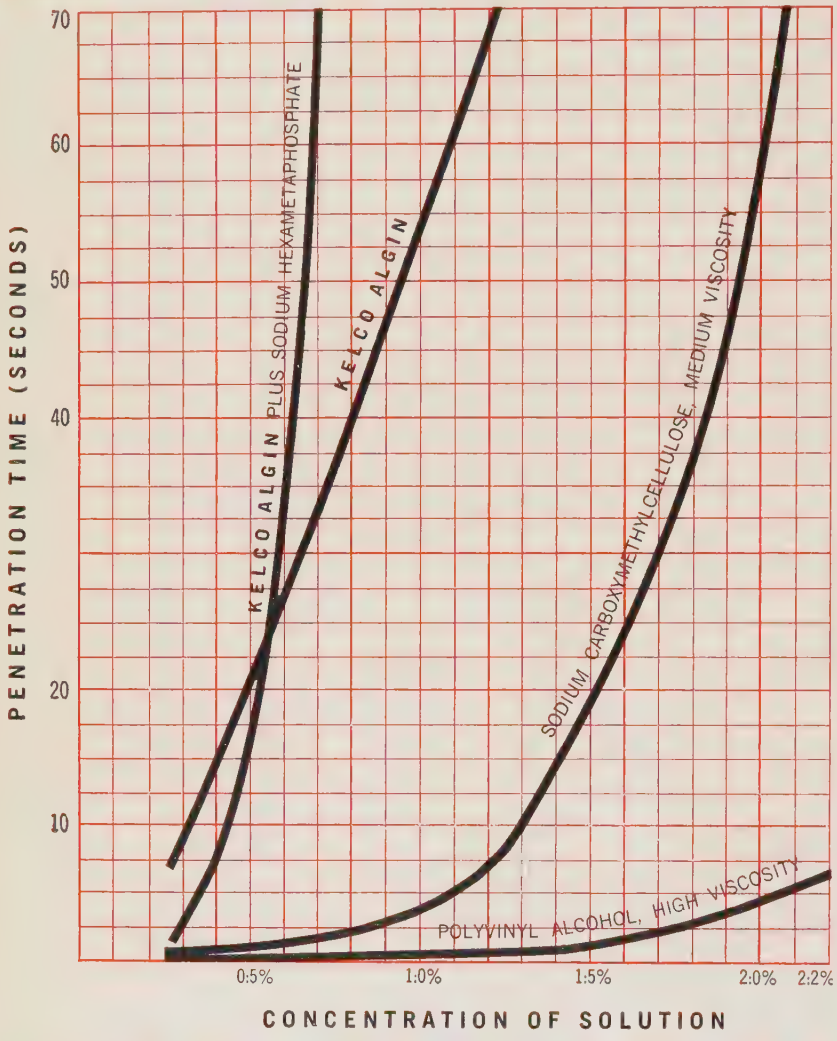
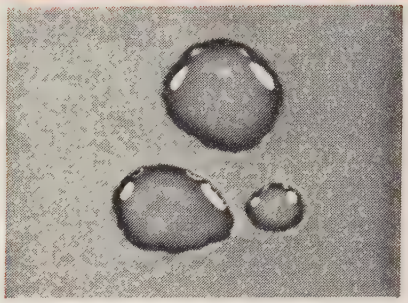
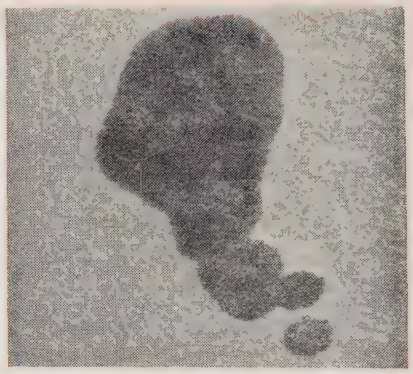
Remarkable! The way Kelco Algins give greater

PENETRATION





This photograph shows a 1% solution of Kelco Algin twenty minutes after being puddled on blotter. Note how algin controls penetration and retains solution on surface of blotter. This test illustrates the outstanding ability of algin to control penetration. With it you can get the exact degree of hold-out desired for sizings, coatings, adhesives, inks, etc.



Here is photograph of water, without algin, on same piece of blotter taken seconds after water was placed on blotter. Note how water passed immediately into blotter compared to controlled penetration of algin solution.

CONTROL

This graph and blotter test illustrate and prove that KELCO ALGIN products are among the most efficient materials available for controlling penetration. By using proper proportions of a product such as KELGIN, KELGIN LV, KELGIN XL or KELSIZE, manufacturers of paper products can regulate the amount of penetration of size formulations, clay and wax coatings, printing inks, adhesives, etc. Of course, having your formulation where you want it, without excessive and unnecessary penetration, saves you money.

MAKE YOUR OWN TEST: Samples, information and technical service, yours on request without obligation.

KELGIN® KELGIN LV KELGIN XL KELSIZE S® products of **KELCO COMPANY**

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The Structure of Paper

I. The Statistical Geometry of an Ideal Two Dimensional Fiber Network

O. KALLMES and H. CORTE

The structure of paper has been defined to be the geometric arrangement of the fibers and interfiber spaces or pores. An approach to describing the structure of paper is to consider that paper consists of a pile of thin layers, i.e., "two-dimensional" (2-D) sheets of which the geometric elements are plainly visible. The geometry of 2-D sheets is described in this article. The structure of 2-D sheets is described in terms of the means and distributions of eight geometric properties which are closely related to the mechanical, optical, and porous properties of paper. The equations were derived from probability theory and can be evaluated in terms of the number of fibers in a sheet and their dimensions. Experiments to verify the equations have been carried out.

PAPER is a complex fiber network formed from a dilute suspension of single fibers. The structural properties of the network depend upon the nature and the pretreatment of the fibers, and on the processes used to form and finish the network. For example, under the same machine conditions, a wet-beaten pulp forms a denser structure than the same pulp free-beaten. The action of every section of the paper machine—the speed and shake of the wire, the pressure applied at the presses and calenders, the rate of drying, etc.,—has some effect on the structure of the final paper.

On the other hand the uses to which paper can be put are largely limited by its structural properties. Its mechanical properties depend primarily on the number of fiber-fiber contacts; its porous properties on the number and size of the interfiber spaces; and its optical properties on its density and roughness. The number of fiber-fiber contacts and pores, the size of the pores, and the density and surface roughness are all structural properties. Thus the structure of the fiber network is both the *cause* of the paper's properties and the *effect* of the papermaking process.

In this investigation we have attempted to define and describe the structure of paper more specifically than has been done in the past. The "structure of paper" has been defined to be the geometric arrangement of the fibers and interfiber spaces. With presently available tools it is extremely difficult to describe the geometry of truly three-dimensional networks. However, the fiber network comprising a sheet of paper is formed stepwise by the action of the table rolls. Once formed, the network is compressed so that in the final paper most of the fibers are oriented at relatively small angles to the plane of the sheet. Because of the manner in which it is produced paper resembles a multilayered two-dimensional network much more closely than a truly three-dimensional one. Therefore, we undertook first to describe the geometry of a thin fiber network in which all the geometric elements are visible, and then approximate the structure of thicker papers by studying the process of piling up these thin sheets. The geometry of the thin sheets is described in this article.

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STATEMENT OF THE PROBLEM

The nature of the problem is best appreciated by studying a photograph of a thin sheet such as the one shown in Fig. 1a. This sheet is a portion of a 2.5 g. per sq. m. handsheet made from an unbeaten spruce sulfite pulp. Its fibers lie in a single plane except at the fiber-fiber contacts. As most of the contacts involve only two fibers and as the total area of the crossings is a small fraction of the sheet area, we have called the thin sheets *two-dimensional*, or 2-D sheets. (An exact definition of a 2-D sheet is given later.)

Two one-sq. mm. areas* of Fig. 1a are shown enlarged in Fig. 2. It is obvious from the figure that the fibers of a 2-D sheet intersect one another to form an irregular network of polygons. The geometric properties of the 2-D sheet which cause its mechanical, porous, and optical properties are the ones which are of interest to the papermaker, and therefore, are the ones we have investigated.

The mechanical properties of 2-D sheets are obviously dependent on the *total number of fiber-fiber contacts* or fiber crossings. (It is assumed that the tensile strength of a single fiber is much greater than that of a single fiber-fiber contact). The strength of 2-D sheets probably is also dependent on the number of fiber crossings by which each fiber is anchored in the network, i.e., *the number of crossings per fiber*. However, it is apparent from Fig. 1a and 2 that (1) the number of crossings per sq. mm. varies over the plane of the sheet (Fig. 2a contains 8 crossings, Fig. 2b, 49 crossings); and (2) the number of crossings per fiber varies from fiber to fiber. We believe that the distribution of the number of fiber crossings per sq. mm. and the distribution of the number of crossings per fiber are among the primary causes of the variations in the strength properties of paper over the area of the sheet.

The distribution of the number of fiber crossings per sq. mm. is due to the variation of the number of fibers or parts of fibers (*fiber segments*) which pass through each sq. mm. square. The variation of the number of fiber segments per sq. mm. is in turn, due to the nonuniform distribution of the fibers, i.e., the fiber centers,

* The sheets were divided into one-sq. mm. squares for part of the investigation. This size of square has no fundamental significance but was chosen for two reasons: (1) it is of the same order of magnitude as the basic structural unit of paper, the fiber; (2) it is the smallest area in which experiments can be carried out conveniently.

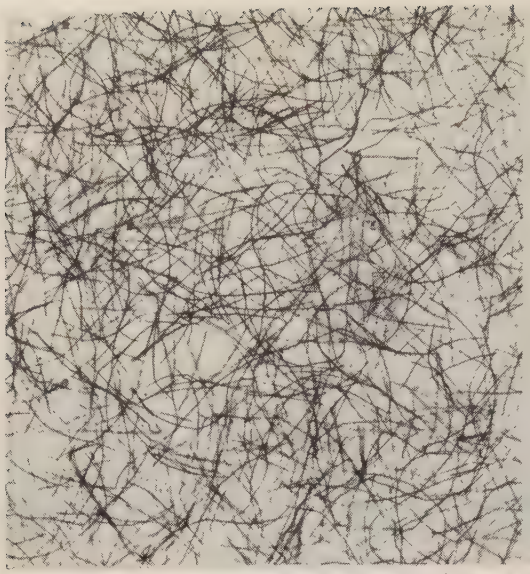


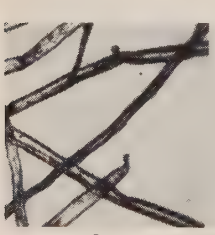
Fig. 1a. 2.5 g. per sq. m. 2-D sheet. (λ = 2.9 mm; τ = 1.1; N/L = 4.9 fibers/mm. Magnification ×4

Fig. 1b. Random network of lines (λ = 3 mm.; τ = 1.0; N/L = 4.9 lines/mm. Magnification ×4

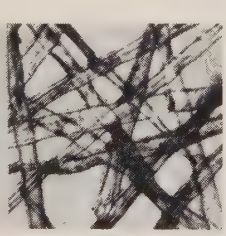
Figure 1a appears more dense than 1b because the fibers have greater width than the lines.

over the sheet. This nonuniform distribution of the fiber centers is in fact one of the basic causes of all of the sheet's nonuniformities.

The distribution of the number of fiber centers per sq. mm. over the sheet is not equivalent to the mass distribution because the fibers are linear extensions of points. Because it is extremely difficult to measure the mass per sq. mm. of a 2-D sheet, and because the mass of a fiber is more or less linearly related to its length, the mass distribution is described here in terms of the distribution of the length of fibrous material per sq. mm.



2a



2b

Fig. 2a. One sq. mm. of Fig. 1a; 8 fiber segments; 6 fiber chords, 2 fiber ends; 8 fiber crossings. Magnification ×40
Fig. 2b. One sq. mm. of Fig. 1a; 16 fiber segments; 13 fiber chords; 3 fiber ends; 49 fiber crossings. Magnification ×40

The distribution of the number of crossings per fiber is due to two causes: (1) the fibers have varying length; (2) the number of fibers crossing a line of unit length varies throughout the sheet. This becomes self-evident when one draws a scanning line across any part of Fig. 1a. The number of fibers crossing a scanning line can also be expressed in terms of the distances between the points where the fibers intersect the scanning line. Because the scanning line can be considered to be a number of end-to-end fibers, the distance between intersections is the distance between crossings along a fiber. We have called this length the free fiber length or gap size. It has been considered because *the means and distributions of the number* (per fiber) *and size of the free fiber lengths* are probably related to some of the mechanical properties of a 2-D sheet (for example, stretch properties).

The means and distributions of the size of the free fiber lengths and of the number of fibers crossing a unit length of the scanning line have been studied for another reason. It will be shown later that all the geometric properties of a 2-D sheet can be determined on the basis of those two distributions.

The porous properties of a 2-D sheet obviously depend on the *number, size, and shape of the polygons.* The number of polygons, and the mean and distribution of the polygon size are easily defined. The shape of irregular polygons is extremely difficult to define and has been characterized in this study only in terms of the mean number of sides per polygon.

The geometric properties *underlined* above are the ones which are described in this article. Equations have been derived which relate these properties to the independent geometric properties of the fibers and the sheet. The independent fiber properties are the given fiber dimensions, i.e., their length, width, and curl. (The curl of a fiber is defined to be the ratio of its actual length to the distance between its ends (*1*).) The independent sheet properties are the ones which can be chosen at will, i.e., the area of the sheet, and its weight or the number of fibers it contains. Relating the geometric properties of a fiber network to the independent fiber and sheet properties is purely a problem in statistical geometry and as such has nothing to do with papermaking. The most suitable tool for solving it is the theory or probability. The basic concepts of probability theory which have been applied in this study are discussed briefly in the following section.

NOMENCLATURE

a	=	Area of small section of sheet, sq. mm.
A	=	Total area of sheet, 200 sq. cm.
a_h	=	Polygon area, sq. cm.
$s(a_h)$	=	Frequency of polygons with area between a_h and $a_h + da_h$.
c	=	Number of crossings per fiber.
$n(c)$	=	Frequency of fibers with c crossings.
g	=	Length of free fiber path, cm.
$r(g)$	=	Frequency of free fiber lengths with length between g and $g + dg$.
$\bar{k}$	=	Mean number of segments into which a fiber is split.

l = Side length of a square of area a, cm.
L = Length of scanning line, cm.
m, M = Length of fibrous material in area a, A, cm.
$l(m)$ = Frequency of squares of area a with total length of fibrous material between m and $m + dm$.
N = Number of fibers intersecting a scanning line.
N', N'' = Number of infinite, finite lines of no width intersecting a scanning line.
n_c, N_c = Number of fiber crossings in area a, A.
N_c', N_c'' = Number of crossings of infinite, finite lines of no width.
$m(n_c)$ = Frequency of squares of area a containing between n_c and $n_c + dn_c$ crossings.
n_{ch}, N_{ch} = Number of fiber chords in area a, A.
n_e, N_e = Number of fiber ends in area a, A.
n_f, N_f = Number of fiber centers in area a, A.
n_g = Number of free fiber lengths per fiber.
$n(n_g)$ = Frequency of fibers with n_g free fiber lengths.
N_h = Number of polygons formed by fibers in area A.
N_h', N_h'' = Number of polygons formed by infinite, finite lines of no width.
n_s, N_s = Number of polygon sides per polygon, in area A.
N_s', N_s'' = Number of polygon sides formed by infinite, finite lines of no width.
n_{seg}, N_{seg} = Number of fiber segments in area a, A.
$p(n_{seg})$ = Frequency of squares of area a containing between n_{seg} and $n_{seg} + dn_{seg}$ segments.
P = Probability of intersection of two fibers in an area A.
P' = Probability of intersection of two fiber segments in area a.
P_{ch} = Probability of an intersection between two chords within a convex area.
P(int.) = Probability of an intersection between two convex shapes of area α_1 and α_2.
r = Fraction of sheet 1-sq. mm. squares containing r fibers.
$p(r)$ = Number of fiber centers in a square of area a.
r' = Number of fibers on top of one another.
$p(r')$ = Fraction of sheet covered by r' fibers on top of one another.
S = Possible number of intersections between pairs of lines.
U = Perimeter of a convex area, cm.
w = Weight of fiber per mm., g. per mm.
W = Basis weight of sheet, g. per sq. m.
Z = Number of lines of grid crossed by a fiber.
α = Projected area of a fiber, sq. cm.
α_c = Projected area of a fiber crossing, sq. cm.
α_1, α_2 = Area of convex shapes, sq. cm.
$(\alpha_{12}]$,int) = Mean common area of α_1 and α_2 provided they intersect, sq. cm.
α_{12} = Mean common area of α_1 and α_2, sq. cm
γ = Constant of proportionality.
ϵ = Point of intersection of fiber and scanning line.
θ = Angle between intersecting straight lines or fibers.
λ = Fiber length, cm.
$\phi(\lambda_i)$ = Frequency of fibers of length class i.
λ_{ch} = Fiber chord length, mm.
λ_e = Fiber end length, mm.
λ_{seg} = Fiber segment length, mm.
τ = Fiber curl factor.
ω = Fiber width, μ

MATHEMATICAL BASIS

Probability theory can best be applied to independent or random events. Thus, we must consider the fibers of a sheet to be formed into a network by a random process which is fulfilled by the following conditions:

1. The fibers are deposited independently of one another.
2. The fibers have an equal probability of landing at all points of the sheet, i.e., the fiber centers are randomly distributed over the area.
3. The fibers have an equal probability of making all possible angles with any arbitrarily chosen, fixed axis, i.e., the fibers have a random orientation.

In Fig. 1b, 970 lines of equal length have been drawn at random on a grid consisting of 10,000 points. The position of the line centers and the orientation of each line with respect to an arbitrarily chosen fixed axis were selected from a table of random numbers (*2*). It is obvious that Fig. 1b is similar in appearance to the 2-D sheet shown in Fig. 1a. The fiber density of Fig. 1a and the line density of Fig. 1b are obviously nonuniform, i.e., the fibers and lines form flocs. However, the papermaker strives to produce an even sheet, one which is uniform throughout. In order to form such a sheet he would have to control the deposition of every fiber. As this is clearly impossible, the most uniform or ideal sheet obtainable is formed by the process giving a minimum of flocculation or fiber interaction, i.e., a random process. This process is approached by forming sheets from extremely dilute suspensions.

Let us consider an area of A sq. mm. divided into A one-sq. mm. squares. When a single fiber is dropped onto the area by a random process, the probability that its center of gravity lands within a given square is $1/A$; the probability that it lands outside the given square is $1-1/A$. If a large number of fibers, N_f, is dropped onto the area the probability that r fibers land within the given square, $p(r)$, is given by the familiar binominal distribution,

$$p(r) = \binom{N_f}{r} \left(\frac{1}{A}\right)^r \left(1 - \frac{1}{A}\right)^{N_f - r} \qquad (1)$$

When N_f is large, $1/A$ small, and N_f/A of moderate magnitude and equal to the mean number of fiber centers per sq. mm., $\bar{n}_f$, equation (1) reduces to the well-known Poisson approximation to the binominal distribution (*3*),

$$p(r) = \frac{[\exp(-\bar{n}_f)]\bar{n}_f{}^r}{r!} \qquad (2)$$

All fibers longer than $\sqrt{2}$ mm. and most of the fibers longer than 0.5 mm. lie in two or more of the one-sq. mm. squares. Thus each one-sq.-mm. square contains a number of fiber segments which pass either entirely through the square (*fiber chords*) or which terminate within the square (*fiber ends*). (Figure 2a contains eight segments, six chords, and two ends; Fig. 2b sixteen segments, thirteen chords, and three ends.) By applying similar considerations to the centers of fiber segments as to the centers of whole fibers, it can be concluded that the distribution of the number of fiber segments per sq. mm. is Poisson with a mean of $\bar{n}_{seg}$ segments per sq. mm.

Consider now a straight line of length L divided into units of equal length (say 1 mm.) drawn at random through a randomly formed network of lines (or fibers). Marking the intersections made by this network with the scanning line is equivalent to the process of choosing the position of points along the scanning line at random. Thus the distribution of the number of fibers intersecting a mm. of the scanning line is also Poisson with a mean of N/L, where N is the total number of fibers intersecting a length L of the scanning line ($L > 1$ mm.).

The distribution of the size of the free fiber length can be derived from the same basic considerations as the Poisson distribution. The probability that the distance between two intersections, g, lies between g and $g + dg$, $r(g)$, is given by the "negative exponential equation,"

$$r(g) = \frac{N}{L} \exp\left(-\frac{N}{L} g\right) dg \qquad (3)$$

Equations (2) and (3) are the equations from which were derived all the distributions of the geometric

Table I. Equations for Overall and Average Values of Geometric Properties

Property	*Symbol*	*Dimension*	*Equation no.*	*Primary equations*	*Equation no.*
Total fiber length per sheet, 200 sq. cm.	M	cm.	4	$M = N_f\bar{\lambda}$	4a
Total no. of fiber crossings per sheet, 200 sq. cm.	N_c	...	5	$N_c = \frac{(N_f\bar{\lambda})^2}{A\pi\bar{\tau}^2}$	5a
Av. no. of fiber crossings per fiber	$\bar{c}$	...	6	$\bar{c} = \frac{2N_c}{N_f}$	6a
Av. no. of free fiber lengths per fiber	$\bar{n}_g$	...	7	$\bar{n}_g = \bar{c}\exp\left(-\frac{\pi\bar{\omega}\bar{c}\bar{\tau}}{2\bar{\lambda}}\right)$	7a
Av. free fiber length	$\bar{g}$	cm.	8	$g = \bar{\lambda}/\bar{c}\bar{\tau}$	8a
Total no. of polygons per sheet, 200 sq. cm.	N_h	...	9	$N_h = (N_c - N_f)\exp\left(-\frac{N_f\bar{\alpha}}{A}\right)$	9a
Av. no. of sides per polygon	$\bar{n}_s$	...	10	$\bar{n}_s = 4$	10a
Av. polygon area	$\bar{a}_h$	sq. cm.	11	$\bar{a}_h = \frac{A}{N_c - N_f}$	11a

properties of a 2-D sheet. The transformations made are shown later.

Some of the equations derived in this investigation are valid only when no more than two fibers cross at a single point. As this limitation is clearly a contradiction of a random process, we have arbitrarily defined a 2-D sheet as one in which the errors caused by this contradiction are small. This definition is as follows:

An ideal fiber network is formed by depositing N_f fibers into an area A by a random process. The mean fraction of A covered by r' fibers is given by the Poisson distribution (see equation 2) with a mean of $N_f\,\bar{\alpha}/A$ where $\bar{\alpha}$ is the mean projected area covered by a single fiber. When the number of fibers in the network is so small that the area covered by more than two fibers is negligible, i.e., less than 1%, the network is defined to be a two-dimensional network. For all practical purposes, no more than two fibers cross at a single point in a 2-D sheet.

EQUATIONS FOR OVERALL AND AVERAGE VALUES OF THE PROPERTIES OF AN IDEAL 2-D SHEET

The overall and average values of the geometric properties of an ideal 2-D sheet underlined in the section "Statement of the Problem" can be calculated from the expressions listed in Table I; the derivations of these equations are given in Appendix I. It should be noted that equations (4–9) and (11), column 5, Table I, the "Primary Equations," contain only the independent fiber and sheet properties, i.e., the mean fiber length $\bar{\lambda}$, the mean fiber width $\bar{\omega}$, the mean curl factor $\bar{\tau}$, the area of the sheet A, and the total number of fibers in the sheet, N_f, or quantities which can be reduced to these terms. Thus, if the fiber dimensions of a pulp are known, the only experiment necessary to determine the means of the geometric properties of a 2-D sheet is the one giving N_f. The value of N_f can be readily determined by counting the total number of fibers intersecting a scanning line drawn across the sheet at random. If a scanning line of length L is intersected by N fibers, the total number of fibers in the area A is:

$$N_f = \frac{\pi A\,\bar{\tau}}{2\bar{\lambda}}\left(\frac{N}{L}\right) \qquad (12)$$

(See Appendix I for the derivation of equation 12.) Substituting equation (12) into equations (4–9) and (11) gives these equations in terms of the fiber properties and the result of the scanning experiment. The substituted equations, called the "Secondary Equations," are listed in column 7 of Table I.

Equation (5), giving the mean or total number of crossings in a sheet, is valid ony when no more than two fibers cross at a point. The reason for this limitation is that equation (5) gives the mean number of crossings made by fibers of no width. Thus where three fibers pass over a point in a real sheet, equation (5) predicts three contacts between the fiber axes whereas only two real fiber contacts occur.

Equations (4–12) were checked experimentally on three handsheets made from a specially prepared spruce sulfite pulp. Sheets no. 1 and 2 were made from the unbeaten pulp and sheet no. 3 from the same pulp after a light mechanical treatment which resulted in a reduction of the fiber length. The calculated and experimental values are listed in columns 8–13 of Table I.

The values of the independent fiber and sheet properties used to calculate the values in Table I are listed in Table II.

DISTRIBUTION OF GEOMETRIC PROPERTIES OF AN IDEAL 2-D SHEET

The distributions of all the properties listed in Table I have not been derived in a completely rigorous manner. In some cases it was not possible to overcome basic mathematical difficulties; in others, a rigorous analysis led to extremely cumbersome numerical expressions. Therefore, the derivations contain some approximations. The distributions are of two kinds considered separately; areal and frequency distributions.

Areal Distributions

The areal distributions show the variations of properties among the one-sq. mm. squares of a sheet. They are:

1. The distribution of the length of fibrous material per sq. mm. over the sheet.
2. The distribution of the number of crossings per sq. mm. over the sheet.

of a 2-D Sheet and Average Values of Geometric Properties of a 2-D Sheet

Secondary equations	Values — Sheet no. 1 calcd.	Sheet no. 1 exptl.	Sheet no. 2 calcd.	Sheet no. 2 exptl.	Sheet no. 3 calcd.	Sheet no. 3 exptl.
$M = \frac{A}{2}\pi\left(\frac{N}{L}\right)$	2394	...	2453	...	1887	1744
$N_c = \frac{A\pi}{4}\left(\frac{N}{L}\right)^2$	7.6×10^5	6.7×10^5	8.0×10^5	...	4.7×10^5	4.9×10^5
$\bar{c} = \left(\frac{\bar{\lambda}}{\bar{\tau}}\right)\left(\frac{N}{L}\right)$	18.5	...	19.0	...	8.8	...
$\bar{n}_v = \left(\frac{\bar{\lambda}}{\bar{\tau}}\right)\left(\frac{N}{L}\right)\exp\left(-\frac{\pi\bar{\omega}N}{2L}\right)$	13.2	...	13.6	...	6.8	...
$g = \frac{N}{L}$	1.44×10^{-2}	1.51×10^{-2}	1.40×10^{-2}	1.32×10^{-2}	1.84×10^{-2}	1.97×10^{-2}
$N_h = \frac{\pi AN}{4L}\left(\frac{N}{L} - \frac{2\bar{\tau}}{\bar{\lambda}}\right)\exp\left(-\frac{\pi\bar{\tau}\bar{\omega}N}{2L}\right)$	4.7×10^5	3.9×10^5	4.9×10^4	...	2.7×10^2	...
.....	4	...	4	...	4	...
$\bar{a}_h = \left[\frac{\pi}{4}\left(\frac{N}{L}\right)\left(\frac{N}{L} - \frac{2\pi}{\bar{\lambda}}\right)\right]^{-1}$	3.0×10^{-4}	3.0×10^{-4}	2.8×10^{-4}	...	5.6×10^{-4}	...

No attempt has been made to derive the distribution of the number of polygons per sq. mm. because a large fraction of them lie in two or more contiguous squares.

All the areal distributions are based on the differential form of the Poisson distribution for the number of segments per sq. mm.:

$$p(n_{seg}) = \frac{[\exp(-\bar{n}_{seg})]\bar{n}_{seg}^{\,n_{seg}}}{n_{seg}!}\, dn_{seg} \qquad (2a)$$

where $p(n_{seg})$ is the fraction of one-sq. mm. squares containing between n_{seg} and $n_{seg} + dn_{seg}$ segments. The distributions of the areal properties are obtained by substituting the relationship between them (i.e., the areal properties) and the number of segments per sq. mm. into equation (2a).* As these relationships are of mean values, which in fact have distributions (generally unknown), the areal distributions are not true distributions, but distributions of means.

1. The distribution of the length of fibrous material per sq. mm. is obtained from equation (2a) and the mean segment length $\bar{\lambda}_{seg}$. The total length of fibrous material in a one-sq. mm. square m, containing n_{seg} segments is equal to:

$$m = n_{seg}\,\bar{\lambda}_{seg} \qquad (13)$$

Substituting equation (13) and its differential form:

$$dn_{seg} = dm/\bar{\lambda}_{seg} \qquad (13a)$$

into equation (2a) gives:

$$l(m) = \frac{[\exp(-\bar{n}_{seg})]\bar{n}_{seg}^{\left(\frac{m}{\bar{\lambda}_{seg}}\right)}}{\bar{\lambda}_{seg}\left(\frac{m}{\bar{\lambda}_{seg}}\right)!}\, dm \qquad (14)$$

where $l(m)$ is the fraction of the one-sq. mm. areas containing a length of fibrous material between m and $m + dm$.

The mean segment length $\bar{\lambda}_{seg}$ is obtained from the following:

Consider a straight fiber of length $\bar{\lambda}$ deposited on a grid of one-sq. mm. squares. It will pass through an average of $\bar{k}$ squares where

$$\bar{k} = \frac{4\bar{\lambda}}{\pi} + 1 \qquad (15)$$

(The derivation of equation (15) is in Appendix II). As the fibers are curled they pass through an average of $\bar{k}/\bar{\tau}$ squares instead of $\bar{k}$ squares. However, it was found experimentally that the effects of fiber curl are only partially accounted for by $\bar{\tau}$. In the equations giving the segment length in terms of fiber properties, the term $(\bar{k}/\bar{\tau})$ had to be corrected by the factor 1/1.1 which is equal to $1/\bar{\tau}$. Thus:

$$\bar{\lambda}_{seg} = \frac{\bar{\lambda}\bar{\tau}^2}{\bar{k}} = \frac{\bar{\lambda}\bar{\tau}^2\pi}{4\bar{\lambda} + \pi} \qquad (16)$$

Over the sheet:

$$\bar{m} = \bar{n}_f\bar{\lambda} = \bar{n}_{seg}\bar{\lambda}_{seg} \qquad (17)$$

Combining equations (16) and (17) gives:

$$\bar{n}_{seg} = \frac{\bar{n}_f\bar{k}}{\bar{\tau}^2} \qquad (18)$$

Thus, the mean number of segments per sq. mm., $\bar{n}_{seg}$, and the mean segment length, $\bar{\lambda}_{seg}$, the terms of equation (14), are reduced to the independent fiber properties and N/L.

2. The areal distribution of the number of crossings per sq. mm. is obtained from equation (2a) and the relationship between the number of segments and crossings per sq. mm.,

$$n_c = {}^1/_2 P' n_{seg}(n_{seg} - 1) \qquad (19)$$

where n_c is the (mean) number of crossings in a one-sq. mm. square, ${}^1/_2\, n_{seg}\,(n_{seg} - 1)$ is the maximum number of intersections which can be made by n_{seg} segments, and P' is the probability that two segments intersect. Solving equation (19) for n_{seg} gives:

$$n_{seg} = {}^1/_2\left(1 + \sqrt{1 + \frac{8n_c}{P'}}\right) \qquad (19a)$$

which on differentation gives:

$$dn_{seg} = \frac{2dn_c}{\sqrt{P'(P' + 8n_c)}} \qquad (19b)$$

* The differential form of the Poisson distribution is used because these substitutions lead to noninteger values of the new variables (see Sample Calculations).

Table II. Independent Fiber and Sheet Properties

Property	Symbol	Dimension	Values		
			Sheet no. 1	Sheet no. 2	Sheet no. 3
Mean fiber length	$\bar{\lambda}$	cm.	0.292	0.292	0.227
Mean fiber width	$\bar{\omega}$	cm.	0.0031	0.0031	0.0031
Mean curl ratio	$\bar{\tau}$	...	1.1	1.1	1.1
Area of the sheet	A	sq. cm.	200	200	200
Total no. of fibers	N_f	...	8.2×10^4	8.4×10^4	10.6×10^4
N_f calcd. from:					
Length of the scanning line	L	cm.	16	16	16
Mean number of fibers intersecting the scanning line	N		1110	1140	870
Basis weight	W	g./sq. m.	2.45	2.88	2.13

Substituting equations (19a) and (19b) into (2a) gives:

$$m(n_c) = \frac{2[\exp(-\bar{n}_{seg})]\bar{n}_{seg}^{1/2}(1 + \sqrt{1 + 8n_c/P'})}{\sqrt{P'(P' + 8n_c)}\,[1/2(1 + \sqrt{(1 + 8n_c/P')})]!}\, dn/_c \tag{20}$$

where $m(n_c)$ is the fraction of the one-sq. mm. squares containing between n_c and $n_c + dn_c$ fiber crossings, and $\bar{n}_{seg}$ is given by equation (18).

In order to evaluate equation (20), P' must be known. P' has one value for the intersection of two fiber chords, a second for fiber ends, and a third for a chord and an end. It is theoretically possible to use three values of P' in equation (20). However, at present P' is only known for the case of intersecting chords. Even if all three P''s were known, substituting weighted values of P' into equation (20) would lead to an extremely cumbersome expression. Therefore an equation for P' for an average mixture of fiber chords and ends has been derived. (See Appendix II):

$$P' = \frac{\pi\bar{n}_f\bar{\tau}^2(k - 1)^2}{8\bar{k}(\bar{n}_f\bar{k} - \bar{\tau}^2)} \tag{21}$$

By applying equations (12), (15), (18), and (21), equation (20) can be evaluated in terms of the independent fiber properties and N/L.

In deriving equations (14) and (20) mean values of the fiber properties and of $\bar{k}$ and $\bar{\lambda}_{seg}$ have been used instead of their distributions. The distributions of the fiber properties cannot be derived but have empirical expressions; the distributions of k and λ_{seg} are as yet unknown. Even if the distributions of k and λ_{seg} were known, it would still be necessary to use experimentally measured histograms for the fiber properties in calculations taking into account all the distributions. This is possible in principle but the numerical calculations involved are extremely complicated. In view of the well-known difficulties involved in measuring fiber properties, these complications are not justifiable.

Frequency Distributions

Frequency distributions describe properties which vary over individual geometric elements, i.e., the fibers and polygons. The frequency distributions considered are:

1. The distribution of the number of crossings per fiber.
2. The distribution of the number of free fiber lengths per fiber.
3. The distribution of the size of the free fiber lengths.
4. The distribution of the areas of the polygons.

It was not possible to derive an expression for the distribution of the number of sides per polygon.

1. The distribution of the number of crossings per fiber is obtained from the Poisson distribution for the number of fibers intersecting a scanning line. Consider the scanning line to be a fiber with a length of λ_i in the ith length class of an experimentally measured fiber-length histogram. Assume that it has a mean curl ratio of $\bar{\tau}$. The mean number of crossing along this fiber is:

$$c_i = \frac{\lambda_i}{\bar{\tau}}\left(\frac{N}{L}\right) \tag{22}$$

The distribution of the number of crossings along a fiber of length λ_i is given by the Poisson distribution with a mean of $N\,\lambda_i/L\,\bar{\tau}$. The distribution of the number of crossings along a fiber of any length is obtained by summing up all the fiber lengths,

$$n(c) = \sum_{i=1}^{\infty} \frac{\left[\exp\left(-\frac{N\lambda_i}{L\bar{\tau}}\right)\right]\left(\frac{N\lambda_i}{L\bar{\tau}}\right)^c}{c!}\,\phi(\lambda_i) \tag{23}$$

where $\phi(\lambda_i)$ is the frequency of the ith fiber length class and $n(c)$ the fraction of fibers crossed by c fibers. (The only neglection made here is the use of a mean curl ratio instead of the distribution of λ_i/τ_i.)

2. The distribution of the number of free fiber lengths per fiber was obtained by substituting equation (7) into the differential form of equation (23). This substitution is of the type used to derive the areal distributions.

$$n(n_g) = \sum_{i=1}^{\infty} \frac{\left[\exp\left(-\frac{N\lambda_i}{L\bar{\tau}}\right)\right]\left(\frac{N\lambda_i}{L\bar{\tau}}\right)^{n_g \exp\left(\frac{\pi\omega N}{2L}\right)}}{\left[\exp\left(\frac{\pi\bar{\omega}N}{2L}\right)\right]\left(n_g \exp\left\{\frac{\pi\bar{\omega}N}{2L}\right\}\right)!}\, dn_g\phi(\lambda_i) \tag{24}$$

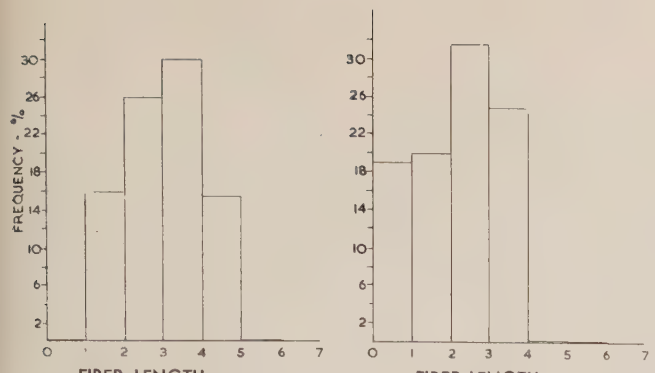
where $n(n_g)$ is the fraction of fibers with n_g gaps.

3. The distribution of the size of the free fiber lengths, g, has already been discussed and is given by equation (3). It should be pointed out that this distribution depends only on N/L and is independent of fiber width (see Appendix II). The importance of this finding is discussed below.

4. The determination of the distribution of the areas of polygons formed by random lines in a plane is an extremely difficult problem. Although a general solution has been found (*4*) it is not possible at present to evaluate it numerically. An approximate solution, based on equation (3), is as follows:

The gap along a fiber between two adjacent intersections with other fibers is the side of two polygons. We have assumed that the area of each polygon, a_h, is proportional, on the average, to the square of the gap length, i.e.:

$$a_h = \gamma g^2, \tag{25}$$



3a 3b

Fig. 3a. Fiber length distribution.
Sheet no. 1 & 2
($\bar{\lambda}$ = 2.92 mm.)

Fig. 3b.
Sheet no. 3
($\bar{\lambda}$ = 2.27 mm.)

where γ is the constant of proportionality. As the distribution of g is known exactly, (equation 3) we have substituted equation (25) and its differential form:

$$dg = \frac{d\,a_h}{2\sqrt{a_h\gamma}} \qquad (25a)$$

into equation (3) to give the distribution of the polygon areas:

$$s(a_h) = \frac{N \exp\left(-\frac{N}{L}\sqrt{\frac{a_h}{\gamma}}\right)}{2L\sqrt{a_h\gamma}}\, da_h \qquad (26)$$

where $s(a_h)$ is the fraction of all polygons having an area between a_h and $a_h + da_h$.

We believe the above substitutions are justified as Miles (*4*) has shown that the distribution of the length of the diameters of the largest circles which can be inscribed tangent to the sides of the polygons of a network of infinitely long, random lines is a negative exponential distribution.

The constant γ of equation (26) is determined by equating the mean polygon area given by equation (26),

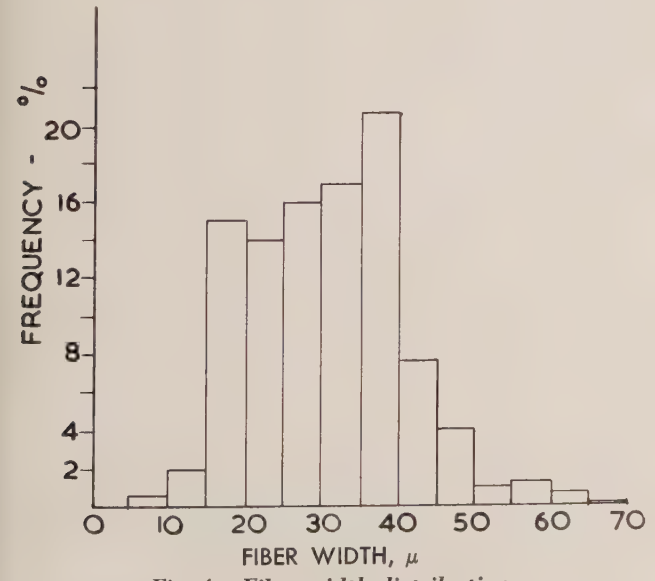


Fig. 4. Fiber width distribution
Sheets no. 1, 2, & 3
($\bar{\omega}$ = 31 μ)

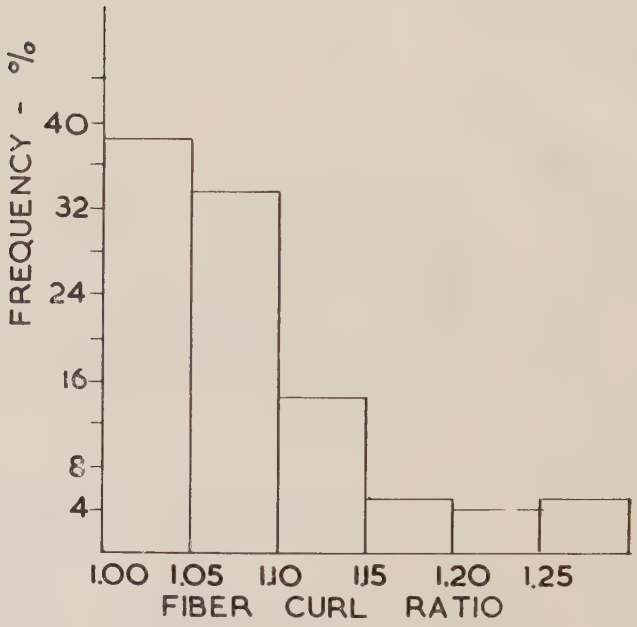


Fig. 5. Fiber curl ratio distribution
Sheets no. 1, 2, & 3
($\bar{r}$ = 1.1)

$$\bar{a}_h = \frac{N}{2L\sqrt{\gamma}}\int_0^\infty \left[\exp\left(-\frac{N}{L}\sqrt{\frac{a_h}{\gamma}}\right)\right]\sqrt{a_h}\, da_h = 2\gamma\left(\frac{N}{L}\right)^2 \qquad (27)$$

to the mean polygon area determined by an independent method, $a_h = A/(N_c - N_f)$ (equation 11). Solving for γ gives:

$$\gamma = \frac{2}{\pi}\,\frac{N/L}{(N/L - 2/\lambda)} \qquad (28)$$

For long fibers ($2/\bar{\lambda} << N/L$) equation (28) reduces to:

$$\gamma = 2/\pi \qquad (28a)$$

As equation (28) contains only N/L and $\bar{\lambda}$, equation (26) can be evaluated in terms of N/L and the independent fiber properties.

The value of γ for a random network of infinitely long lines (equation 28a) is the same as the one Goudsmit (*5*) obtained for this case.

One feature of equation (26) is that, like the gap size distribution, it depends only on N/L (and γ) and is independent of the fiber width. In other words, assuming equation (25) is correct, the polygon size distribution of a 2-D sheet is almost independent of the nature of the fibers (there is a small correction containing $\bar{\lambda}$ in the constant γ).

EXPERIMENTAL WORK

Preparation of Pulp

A special pulp was prepared for this investigation in order to obtain uniformly cooked, undamaged fibers, free of debris. The preparation of the pulp was carried out at the Tropical Products Institute, London.

Spruce chips ($^5/_8$ in.) were cooked in a Wejerk digester by the calcium-base sulfite process. The cooking liquor contained 5.9% total SO_2, 4.7% free SO_2, and 1.2% combined SO_2. The chips were not blown from the digester, but removed manually after the temperature had dropped to below 100°C.

The cooked chips were broken up by pressing between six successive washes with warm water. The

Fig. 6. Microdensitometer scanning recording

pulp was screened twice in a Somerville fractionator fitted in the first run with 0.01-in. flat screen and in the second run with a 24-mesh screen. Between screenings the pulp was treated for 10 min. in a 15 liter disintegrator at a consistency of 0.1%. The overall yield of the two screenings was about 50%. A microscopic examination of the pulp after screening revealed an almost complete absence of ray cells and debris and only a negligible number of cut fibers.

The pulp had a Schopper wetness of 12 and a specific surface of 8800 sq. cm. per g. The specific surface was measured in a constant-pressure permeability cell.

Sheets no. 1 and 2 were formed from the unbeaten pulp. Sheet no. 3 was formed from the same pulp after it had been treated in a 2-liter disintegrator at a consistency of 1% for 2.33 hr. Because all the fines were lost in the formation of the 2-D sheets, the handsheet pulp of sheet no. 3 had a wetness of 12 and a specific surface of 9800 sq. cm. per g.

Preparation of 2-D Sheets

The 2-D sheets were prepared according to TAPPI Standard T 220 m-58 modified as follows:

1. 0.05 g. of pulp was used instead of 1.2 g.
2. The sheets were pressed once for 10 min. at 100 p.s.i.
3. The dried 2-D sheets were scraped from the steel plates with a razor blade. It was possible to remove only about half of the sheets intact in this manner; the remainder tore and were discarded.

The consistency of the fibers in the sheet-forming mould was 7×10^{-4} %. If this number of fibers each occupied a sphere with a diameter equal to their length (~3 mm.), only one-sixth of the sheet mould would have been filled. We believe that under these conditions fibers move almost completely independently of each other and the formation of the 2-D sheets approached a random process.

Measurement of Independent Properties

The fiber-length and fiber-width distributions were measured with a calibrated wheel and a micrometer eye piece, respectively. The curl was determined from 200 measurements of the actual fiber length and the distance between the two fiber ends. The results are shown in Figs. 3–5; the means are listed in Table II.

The number of fibers in the sheets was calculated from equation (12). The term (N/L) was evaluated by scanning the sheets with a Joyce-Loebl double-beam recording microdensitometer, model E12MKIII. In this instrument the sheet is mounted on a carriage which passes slowly over a collimated light beam. After passing through the sample, the beam is focused onto a photomultiplier which records the optical density of the sample. When a 2-D sheet is scanned a peak is recorded as each fiber passes into the field of view of the light beam. A typical recording is shown in Fig. 6.

Measurement of Geometric Properties of 2-D Sheets

The means and distributions of the geometric properties of the 2-D sheets were measured experimentally by the following procedure. Portions of the sheets were mounted between glass slides and projected at a magnification of 60X onto a screen marked off into 6 by 6-sq. cm. squares. All the fibers in an area of 5.28 sq. cm. (sheet no. 1) and 6.30 sq. cm. (sheet no. 3) were drawn on the screen. In sheet no. 1, the fiber crossings in each square were counted; in sheet no. 3 the fiber crossings, fiber ends, and number of segments. The length of each segment in sheet no. 3 was measured with a calibrated wheel. Lines were drawn across the screen at 6 cm. intervals in two mutually perpendicular directions. The distance between fiber crossings was measured, and the number of fibers crossing each 6 cm. unit was counted along these lines.

The polygon size distribution was measured by cutting out and weighing 4304 polygons of a greatly enlarged photograph of sheet no. 1. The distribution of the number of sides per polygon was measured by noting the number of sides of each polygon.

RESULTS

The experimental program had two goals: the justification of the assumptions made in the analysis of the problem; and the verification of the derived equations.

Justification of Assumptions

Check for Randomness and 2-D Nature of Hand-

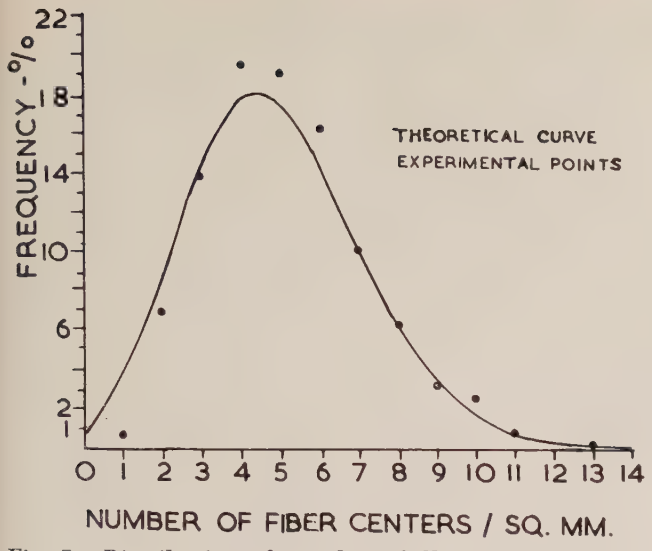


Fig. 7. Distribution of number of fiber centers per sq. mm.

Sheet no. 3
($\bar{n}_f = 4.9$)

sheets. The most important assumptions which had to be verified were the ones dealing with the *randomness* and *2-D nature* of the handsheets.

The random arrangement of the fibers over the area of the sheets was verified by showing that the distribution of the fiber centers per sq. mm. is a Poisson distribution. Because it is difficult to locate fiber centers, and because each fiber has exactly two ends which are easily identifiable in a 2-D sheet, the number of fiber ends per sq. mm. was counted and divided by two. The theoretical curve, based on $\bar{n}_f = 4.9$, and the measured curve for sheet no. 3 are shown in Fig. 7; the agreement between them is good.

The random fiber orientation was checked by scanning the sheets in different directions. If the fiber orientation is random, the number of fibers intersecting a unit length of scanning line is independent of the direction of scanning. In sheet no. 2, there were 71.3 and 71.5 fibers per cm. in two mutually perpendicular directions; in another sheet, not described in this article, there were 106, 97.6, and 97.1 fibers per cm. in three directions 60° apart. Thus, we concluded that the sheet formed for this investigation had no preferential fiber orientation.

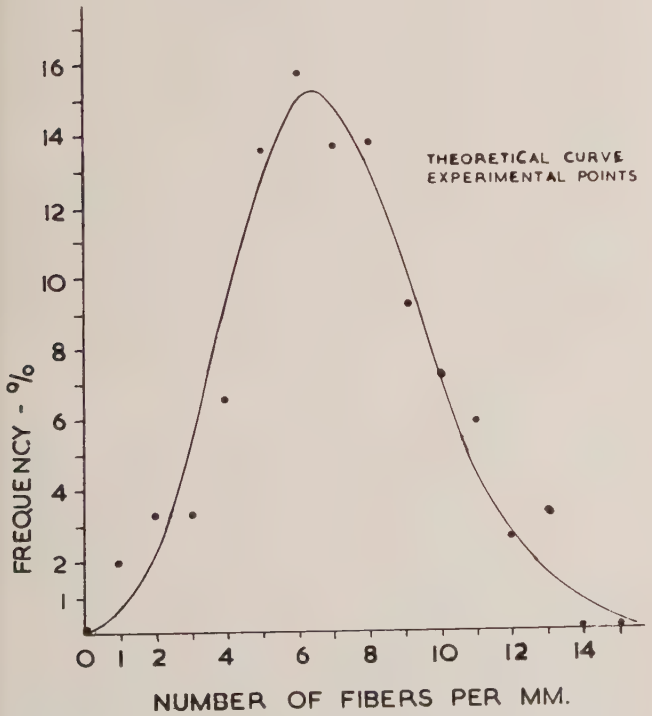


Fig. 8a. Distribution of number of fibers per mm. intersecting a scanning line

Sheet no. 1
($N/L = 6.9$ fibers/mm.)

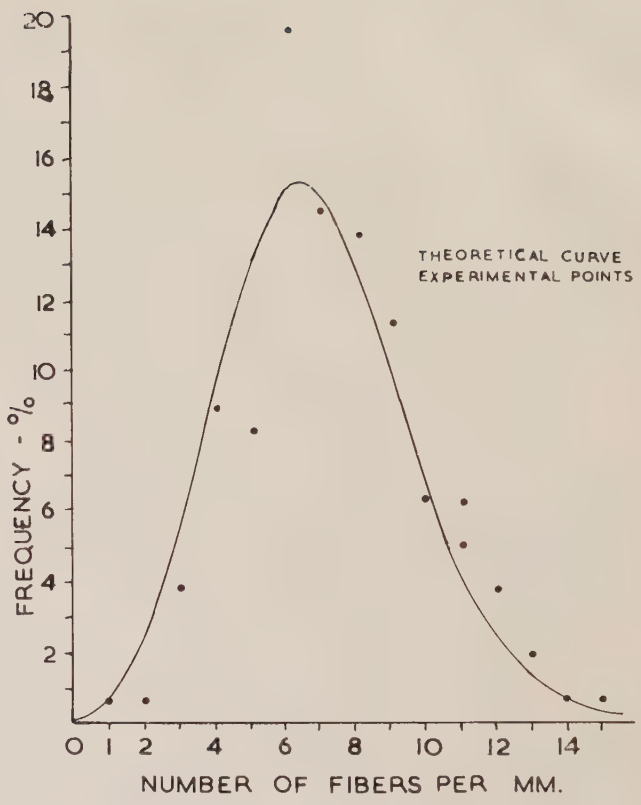


Fig. 8b. Distribution of number of fibers per mm. intersecting a scanning line

Sheet no. 2
($N/L = 7.1$ fibers/mm.)

The close correlation between the theoretical and measured distributions of the number of fibers per mm. of scanning line (Fig. 8) and the correlation between the theoretical and measured gap size distributions (Fig. 9) also indicate randomness in a general manner.

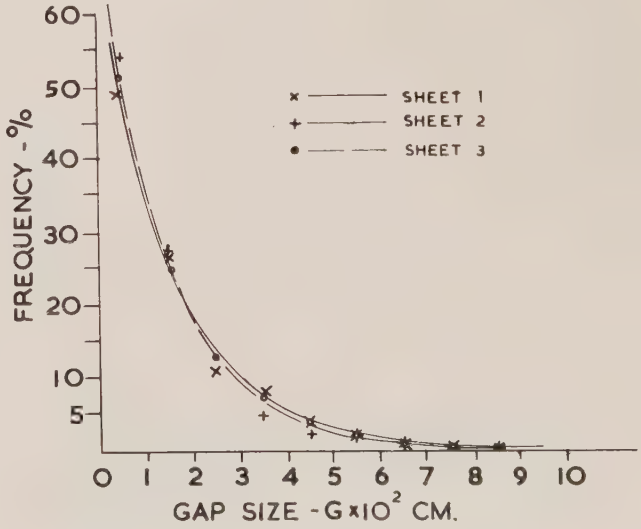


Fig. 9. Distribution of free fiber length

Sheet nos.	1	2	3
$L/N =$	1.44	1.40	1.84×10^{-2}cm.

Table III. Equations for Miscellaneous Geometric Properties of a 2-D Sheet

No.	Property	Symbol	Dimension	Equation	Equation no.	Sheet no. 3 Calcd.	Sheet no. 3 Exptl.
1.	Mean no. of fiber segments per fiber	$\bar{k}/\bar{\tau}$	...	$\frac{\bar{k}}{\bar{\tau}} = \left(\frac{4\bar{\lambda}}{\pi} + 1\right)\frac{1}{\bar{\tau}}$	...	2.96	2.92
2.	Mean no. of fiber segments per sq. mm.	$\bar{n}_{seg}$	...	$\bar{n}_{seg} = \bar{n}_f\bar{k}/\bar{\tau}^2$	18	14.3	14.3
3.	Mean number of fiber chords per sq. mm.	$\bar{n}_{ch}$	...	$\bar{n}_{ch} = \bar{n}_f\left(\frac{\bar{k}}{\bar{\tau}^2} - 2\right)$	...	3.66	4.87
4.	Mean number of fiber ends per sq. mm.	$\bar{n}_e$	...	$\bar{n}_e = 2\bar{n}_f$	...	10.6	9.8
5.	Ratio of chords/ends	$\bar{n}_{ch}/\bar{n}_e$	...	$\frac{n_{ch}}{\bar{n}_e} = \frac{4\bar{\lambda} + \pi(1 - 2\bar{\tau}^2)}{2\pi\bar{\tau}^2}$	A14	0.35	0.32
6.	Mean length of fiber segments	$\bar{\lambda}_{seg}$	mm.	$\bar{\lambda}_{seg} = \bar{\lambda}\bar{\tau}^2/\bar{k}$	16	0.67	0.66
7.	Mean length of fiber chords	$\bar{\lambda}_{ch}$	mm.	$\bar{\lambda}_{ch} = \frac{\pi\bar{\tau}}{4}$	A15	0.86	0.78
8.	Mean length of fiber ends (4)	$\bar{\lambda}_e$	mm.	$\bar{\lambda}_e = \frac{\overline{\lambda_{ch}^2}}{2\bar{\lambda}_{ch}}$	A18	0.52	0.51
9.	Ratio chord-length/end-length	$\bar{\lambda}_{ch}/\bar{\lambda}_e$	...	$\bar{\lambda}_{ch}/\bar{\lambda}_e = 1.67$	...	1.67	1.52
10.	Mean probability of 2 segments intersecting	P'	...	$P' = \frac{\pi\bar{n}_f\bar{\tau}^2(\bar{k} - 1)^2}{8\bar{k}(\bar{n}_f\bar{k} - \bar{\tau}^2)}$	21	0.244	0.252
11.	Fractional open area of the sheet*	$p(0)$	...	$p(0) = \exp\left(-\frac{N_f\bar{\alpha}}{A}\right)$	...	0.69	0.60
12.	Mean area of a fiber** crossing	$\bar{\alpha}_c$	sq. cm.	$\bar{\alpha}_c = \frac{\pi}{2}\bar{\omega}^2$	29	1.6×10^{-6}	1.4×10^{-5}

* Data for sheet no. 1.
** Calcd. from $p(>2)/N_c$.

It was stated above that a 2-D sheet is defined to be one in which less than 1% of the area is covered by more than two fibers, i.e., $p(\geq 3) < 0.01$. This definition was checked by calculating the uncovered area, $p(0)$, the area covered by single fibers, $p(1)$, and $p(2)$, and $p(\geq 3)$ from the Poisson distribution with a mean of $N_f\,\bar{\alpha}/A$. Using values of sheet no. 1—$N_f = 8.2 \cdot 10^4$; $\bar{\alpha} = 9.05 \times 10^{-4}$ sq. cm.; and $A = 200$ sq. cm.—$p(0) = 0.690$, $p(1) = 0.256$, $p(2) = 0.047$, and $p(\geq 3) = 0.007$. For sheets no. 2 and 3, $p(\geq 3)$ was 0.007 and 0.003 respectively. Thus we concluded that sheets no. 1–3 were 2-D sheets.

$p(0)$ was verified experimentally by measuring the fractional open area of sheet no. 1. (This measurement was made by cutting out and weighing the polygons of a photograph of the sheet.) The experimentally determined value of 0.60 was considered to be in good agreement with the theoretical value of 0.69 in view of the difficulties involved in cutting and weighing the photographs of the polygons.

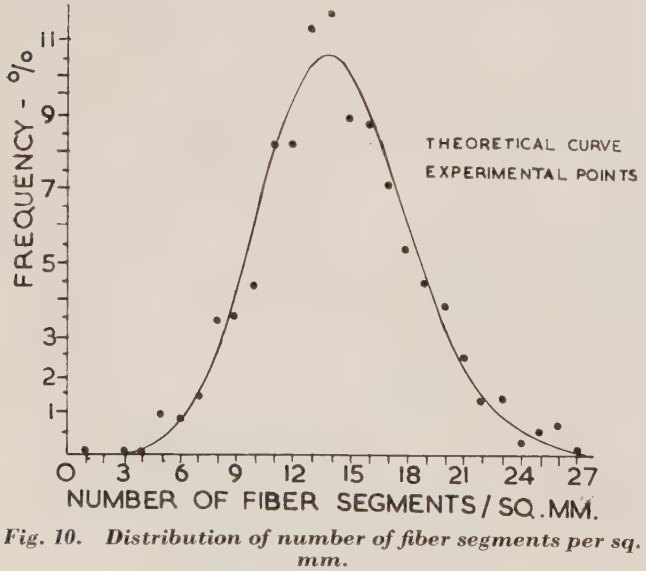


Fig. 10. Distribution of number of fiber segments per sq. mm.
Sheet no. 3
($\bar{n}_{seg} = 14.3$)

Other Assumptions. The areal distributions are based on the assumption that the distribution of the number of fiber segments per sq. mm. is a Poisson distribution; the theoretical and experimental curves for sheet no. 3 are shown in Fig. 10 and are in excellent agreement. The mean of the theoretical curve, $\bar{n}_{seg} = 14.3$, was calculated from equation (18) and agreed with the experimentally measured value (see Table III).

In the course of the investigation, equations for a large number of miscellaneous properties of fiber segments in one-sq. mm. squares were derived and checked experimentally. The excellent agreement between the theoretical and measured values of these properties, listed in Table III, lend considerable support to the validity of the overall approach to the problem.

Check of Equations

Check of Equation (12). As all the means are based on the determination of N_f (equation 12), it was necessary to check this value independently. Two different checks were made.

(a) The number of fibers in sheet no. 3 was counted directly by dividing by two the counted number of fiber ends. The value found, 4.9 fibers per sq. mm., agreed well with the value of 5.3 fibers per sq. mm. obtained by scanning equation (12).

(b) An indirect check for N_f was obtained by comparing among the three sheets the weight per mm. of fiber from N_f, $\bar{\lambda}$, and the basis weight. The close agreement of the three values 2.0×10^{-7}, 2.3×10^{-7},

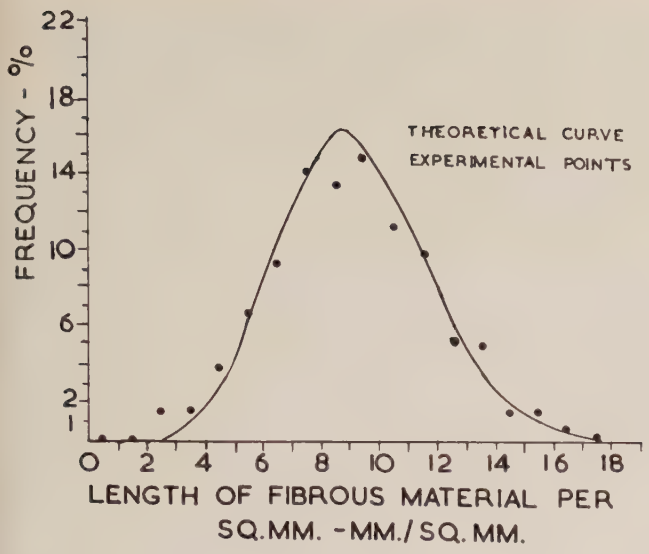


Fig. 11. Distribution of length of fibrous material per sq. mm.

Sheet no. 3
($\bar{m}$ = 9.45 mm./sq. mm.)
($\bar{n}_f$ = 4.9; $\bar{\lambda}$ = 1.78 mm)

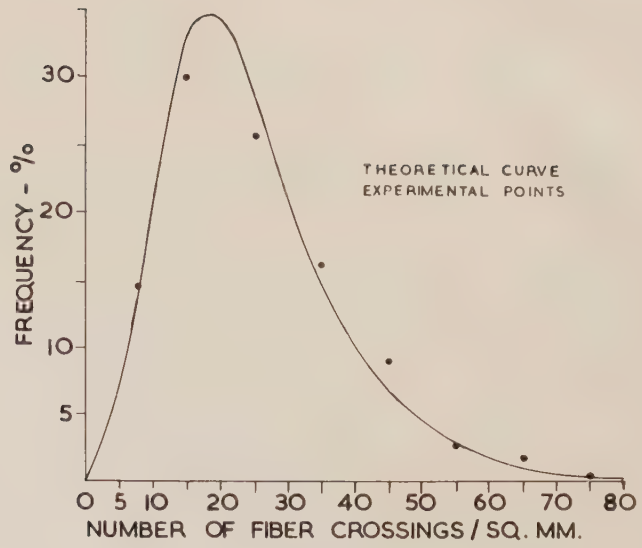


Fig. 12b. Distribution of number of fiber crossings per sq. mm.

Sheet no. 3
($\bar{n}_{seg}$ = 14.3; $\bar{P}$ = 0.244)

and 2.3×10^{-7} g. per mm. indicates that the values of N_f and $\bar{\lambda}$ are correct.

Areal Distribution and Their Means. The theoretical and measured areal distributions are shown in Figs. 11 and 12; in all cases, the agreement was good. For sheet no. 1, the measured crossings distribution agrees more closely with the theoretical curve based on a value of ($\bar{n}_{seg}$ = 15) calculated from equation (19) and the measured $\bar{n}_c$ than with the truly theoretical curve; the latter is based on a value of ($\bar{n}_{seg}$ = 16) calculated from equation (18). This discrepancy is due to an experimental error made in counting the crossings of sheet no. 1. The error was eliminated in the counting of the crossings of sheet no. 3.

Frequency Distribution and Their Means. The theoretical and measured frequency distributions, shown in Figs. 9 and 14 are in excellent agreement. The distribution of the number of crossings per fiber, Fig. 13, was not checked experimentally; it is included only to show how a fiber length histogram can be fitted into a distribution.

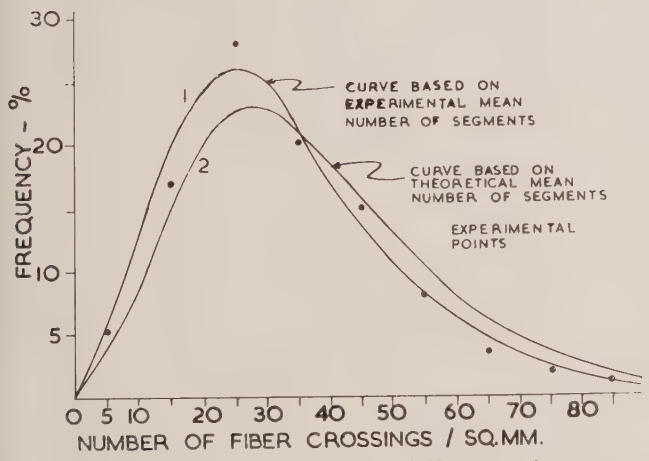


Fig. 12a. Distribution of number of fiber crossing per sq. mm.

Sheet no. 1
Curve no. 1 ($\bar{n}_{seg}$ = 15)
Curve no. 2 ($\bar{n}_{seg}$ = 16)
$\bar{P}$ = 0.313

Distribution curves for the number of free fiber lengths per fiber were not drawn because no experimental evidence was gathered.

The distribution of the number of sides per hole was measured experimentally to confirm the prediction that $\bar{n}_s = 4$. It was found that 52% of the polygons were triangles, 36% tetragons, and 12% had more than four sides. Although the number of sides of the polygons of the more-than-four class were not counted their average must be 8.4 if $\bar{n}_s = 4$. Because 88% of the polygons were 3- or 4-sided and the $\bar{n}_s$ of the remainder was 8.4, we concluded that equation (10) was verified experimentally.

The constant γ of the hole size distribution was evaluated by equating equations (11) and (27). However, γ has a theoretical basis as it is the constant which relates the area of a polygon to the square of its mean side length; γ is a maximum for regular polygons. It is equal to 0.433 for equilateral triangles and 1 for

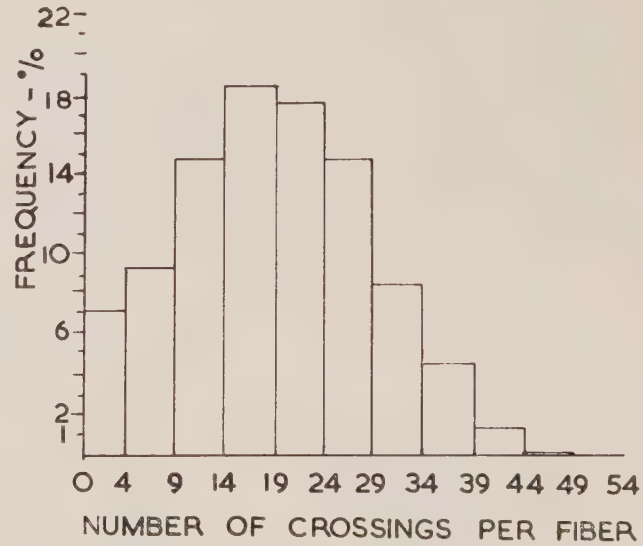


Fig. 13. Distribution of number of fiber crossings per fiber

Sheet no. 1
(N/L = 6.93)

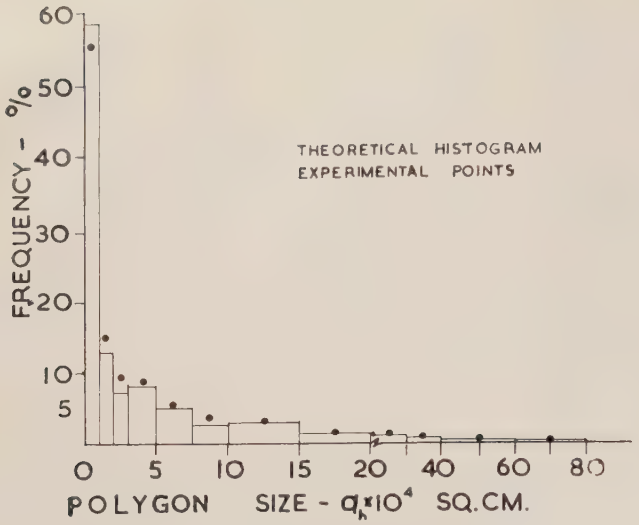


Fig. 14. Distribution of polygon size
Sheet no. 1
($\bar{a}_h = 3.0 \times 10^{-4}$ sq. cm.)

squares. Because 88% of the polygons were 3- or 4-sided, γ ought to be less than 1; the value of γ calculated from equation (28) was 0.7.

The agreement between the theoretical and measured free fiber length distributions and the theoretical and measured hole size distributions confirms equations (3) and (26).

Evaluation of Data

The agreement between the theoretical and the measured values of the overall and average geometric properties in Tables I and III and between the theoretical and measured distribution curves were considered to be very good. As only three sheets were investigated in detail, it was not possible to apply statistical tests to the data. However, each experimental value was an average of hundreds, and in many cases, thousands of measurements. As excellent agreement was obtained in every one of a large variety of geometric properties, we concluded that the agreement was not accidental, and that the equations have been verified.

DISCUSSION AND CONCLUSIONS

The structure of a sheet of paper has been defined to be the geometric arrangement of the fibers and interfiber spaces or pores. Because of its complexity, the structure of papers of ordinary thickness cannot be described directly. We believe it can best be approximated by studying the process of piling up layers of 2-D sheets; the geometry of the 2-D sheets is described in this article.

The geometric analysis was based on the hypothesis that a 2-D sheet produced under ideal conditions is formed by a random process. Such a network is characterized by not having a uniform distribution of fibers but a certain amount of non-homogeneity or flocculation. *This flocculation is an inherent property of an ideal random process.*

The equations describing the 2-D sheets were derived through the application of probability theory. Although some are of an approximate nature they should be generally valid for random networks of all types of fibers (and straight lines). Their evaluation requires only a knowledge of the independent fiber and sheet properties. In other words, an ideal, random 2-D sheet of paper is completely described by the statement that *it contains N_f fibers of length $\bar{\lambda}$, width $\bar{\omega}$, and curl $\bar{\tau}$ deposited on a plane of area A by a random process.* Further details of the sheet can be evaluated from the equations derived in this article, but these equations are in fact only special forms of the underlined statement.

The equations are limited to sheets of certain basis weights by the definition of a 2-D sheet and by the dimensions and weight of the fibers. This maximum basis weight has been evaluated for two definitions of a 2-D sheet and for a number of typical commercial pulps (see Table IV). It was found that the maximum basis weight up to which the results are valid when p (≥ 3) is less than 1% is 1.5 to 2.5 g. per sq. m.; when p (≥ 3)<5%, 3 to 5 g. per sq. m.; and for the pulp used in this investigation, 2 and 6 g. per sq. m. for the two definitions of p (≥ 3). The larger maximum basis weights of the 2-D sheets of the specially prepared pulp are due to the greater weight per unit length of these fibers, 2.2×10^{-7} g. per mm. vs. $0.8 \times 10^{-7} - 1.5 \times 10^{-7}$ g. per mm. This difference in weight per unit length of fiber reflects the absence of fines, ray cells, and debris from our pulp.

In spite of the above limitations it is possible to draw a number of conclusions. This is best done from an examination of the "Primary Equations" of Table I. If the minor term N_f of the equations for N_h and a_h is neglected it will be seen that four of the seven geometric properties depend only on $N_f \bar{\lambda}$; of the other three one depends only on $N_f \bar{\lambda}$ and $\bar{\lambda}$, a second on $N_f \bar{\lambda}$ and $\bar{\omega}$, and the third on $N_f \bar{\lambda}$, $\bar{\lambda}$ and $\bar{\omega}$.

The product, $N_f \bar{\lambda} = M$ is the total length of fibrous material in a sheet, i.e., it is the fiber density. Thus at constant M, the total number of crossings, N_c, the mean gap length, $\bar{g}$, and the mean polygon area, $\bar{a}_h$, are independent of the fiber dimensions. Increasing M will increase N_c and decrease $\bar{g}$ and $\bar{a}_h$. These

Table IV. Maximum Basis Weight of 2-D Sheets from Various Pulps

No.	Pulp	Mean fiber length, mm.	Mean fiber width, mm.	Estimated no. of fibers per g. (millions)	Mean fiber weight per unit length (g./m. × 10^7)	Maximum basis weight (g./sq. m.) $P(>2) < 0.01$	Maximum basis weight (g./sq. m.) $P(>2) < 0.05$
1.	Southern pine unbleached kraft	2.12	0.036	3.97	1.2	1.4	2.7
2.	Softwood paper grade alpha	0.98	0.023	6.90	1.5	2.8	5.3
3.	Hardwood bleached sulfite	0.18	0.018	59.1	1.1	2.3	4.2
4.	Hardwood paper grade alpha	0.35	0.018	37.9	0.8	1.8	3.4
5.	Manila, macerated	3.60	0.017	2.70	1.0	2.6	4.9
6.	Cotton rag filter paper	0.58	0.020	16.0	1.0	2.4	4.4
7.	Experimental pulp for sheet nos. 1 and 2	2.92	0.031	1.71	2.2	2.9	5.4
8.	Same for sheet no. 3	2.27	0.031	2.44	2.3	3.2	6.0

Data in columns 3, 4, and 5 for pulps no. 1–6 from Isenberg (*9*).

changes will improve the mechanical strength and lower the porosity of 2-D sheets.

Increasing M at constant $\bar{\lambda}$ and $\bar{\omega}$ will also change $\bar{c}$, $\bar{n}_g$, and N_h in a manner which will also increase mechanical properties and diminish porosity.

Changes in $\bar{\lambda}$ and $\bar{\omega}$ at constant M have two important effects. Decreasing $\bar{\lambda}$ is fiber cutting and this change diminishes $\bar{n}_g$ and $\bar{c}$ (without of course affecting N_c). Therefore losses in strength properties due to fiber cutting will be due to a decrease in the number of fibers holding each fiber in the network.

Changes in $\bar{\omega}$ affect only $\bar{n}_g$ and N_h. Increasing $\bar{\omega}$ at constant M decreases the total number of polygons in the sheet but not their mean size. Thus differences in the porosity of 2-D sheets (with the same value of M) made from pulps with fibers of different widths are due to differences in the number of polygons but not to differences in their size.

The above conclusions can also be drawn from the distributions. The main value of the distributions will come in the analysis of the variations of the mechanical, porous, and optical properties over the sheet.

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APPENDIX I

DERIVATION OF EQUATIONS (3), (5), (6), (7), (9), (10), (11) and (12)

***Equation* (12)**

Consider a fiber of length $\bar{\lambda}$ and curl ratio $\bar{\tau}$ intersecting a scanning line (see Fig. 15). The length of the straight line between the fiber ends is $\bar{\lambda}/\bar{\tau}$, and the angle between this line and the scanning line is θ. The projection of the line on the perpendicular to the scanning line is $(\bar{\lambda}/\bar{\tau})\sin\theta$. For random orientation the angular distribution function is

$$f(\theta)d\theta = \frac{d\theta}{\pi},$$

where, for reasons of symmetry, only half the circle is considered. The average projection of fibers on the perpendicular to the scanning line is

$$\int_0^{\pi} \frac{\bar{\lambda}}{\bar{\tau}} |\sin\theta| \frac{d\theta}{\pi} = \frac{2\bar{\lambda}}{\pi\bar{\tau}}$$

If N fibers intersect a scanning line of length L, the N fibers occupy an area of $2\bar{\lambda}L/\pi\bar{\tau}$. Thus, the mean number of fibers occupying an area A is

$$N_f = \frac{A}{2\bar{\lambda}L/\pi\bar{\tau}} N = \frac{A\pi\bar{\tau}}{2\bar{\lambda}} \left(\frac{N}{L}\right) \qquad (12)$$

***Equation* (5). (4)**

Let N_f fibers fall at random onto a plane of area A. The number of intersections between them is

$$N_c = PS \qquad (A1)$$

where P is the probability that two fibers intersect, and S is the number of ways in which pairs of fibers can be selected.

To calculate P, consider a straight fiber of length $\bar{\lambda}/\bar{\tau}$ fixed in position in the plane. Consider another fiber dropped onto the plane at random. Identify the fall of the fiber by an end point and the angle ($0 \leqslant \theta \leqslant 2\pi$) which it makes with the fixed fiber (see Fig. 16).

Given that the second fiber falls with an angle θ, the probability that it intersects the fixed fiber is $(\bar{\lambda}^2/\bar{\tau}^2)|\sin\theta|/A$. Thus the probability of an intersection is:

$$P = \frac{\bar{\lambda}^2}{\bar{\tau}^2 A} \int_0^{\pi} |\sin\theta| \frac{d\theta}{\pi} = \frac{2\bar{\lambda}^2}{\pi A \bar{\tau}^2} \qquad (A2)$$

To calculate S of equation (A1) consider one of the N_f fibers. It can intersect all of the fibers of the network except itself or make $(N_f - 1)$ intersections. Considering all of the N_f fibers gives $N_f(N_f - 1)$ combinations of two fibers. As each fiber is counted twice:

$$S = {}^1/_2 N_f(N_f - 1) = {}^1/_2 N_f^2 \text{ (when } N_f \gg 1) \qquad (A3)$$

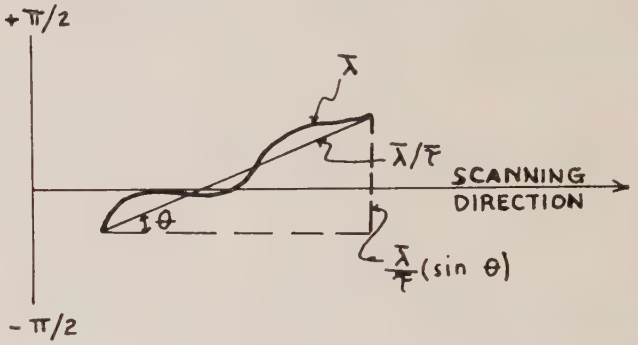

Fig. 15

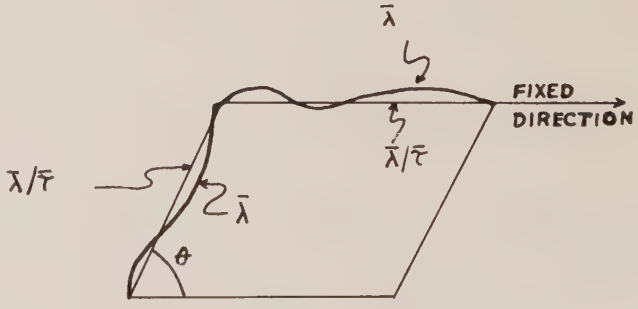

Fig. 16

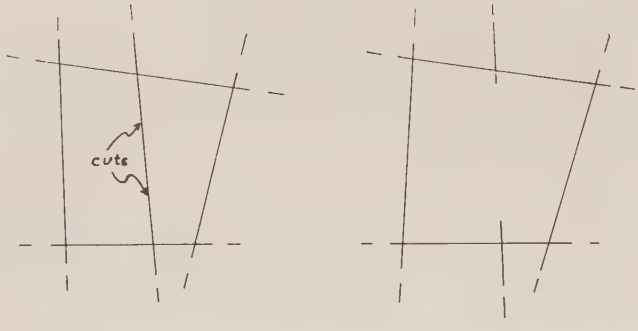

Fig. 17

Combining equations (A1), (A2), and (A3) gives:

$$N_c = \frac{(N_f\bar{\lambda})^2}{\pi A \bar{r}^2} \tag{5}$$

***Equations* (7), (9), (10), *and* (11). (4)**

Goudsmit (5) has derived equations for N_s' and N_h' for the case of infinitely long lines of no width, each of which intersects all of the others (i.e., P=1). (Throughout this section, the primes refer to properties of infinite lines of no width; the double primes to finite lines of no width.)

$$N_s' = {}^1/_2 N'(N'+1) = {}^1/_2 N'^2 \text{ (when } N' \gg 1) \tag{A4}$$

$$\bar{n}_s' = \frac{N_s'}{N_h'} = 4 \text{ (when } N' \to \infty) \tag{A5}$$

From equations (A1) and (A3),

$$N_c' = {}^1/_2 N_f'^2 \tag{A3a}$$

Therefore,

$$N_c' = N_h' \text{ and} \tag{A6}$$

$$N_s' = 4N_c'. \tag{A7}$$

The network of infinitely long lines is changed into one of finite lines by the line-cutting operation shown in Fig. 17. In this operation, two tetragons with eight sides are changed into one with four sides. Similarly $\Delta n_s = 4$ when a line passing through an n-sided polygon is cut. Thus equation (A5) remains unchanged; i.e.:

$$\bar{n}_s'' = \frac{N_s''}{N_h''} = 4 \tag{A5a}$$

At the two end-intersections of each line, four sides were lost so that for these cases:

$$\left[\frac{N_s''}{N_c''}\right]_{\text{ends}} = 2 \tag{A7a}$$

As N'' lines form $2N''$ crossings involving ends and $(N_c'' - 2N'')$ other crossings, the ratio N_s''/N_c'' is

$$\frac{N_s''}{N_c''} = \frac{4(N_c'' - 2N'') + 2(2N'')}{N_c''}$$

or

$$N_s'' = 4(N_c'' - N'') \tag{A8}$$

Substituting equations (A5a) into (A8) gives:

$$N_h'' = (N_c'' - N'') \tag{A9}$$

Equation (A9) is valid only for lines of no width. The factor by which it must be corrected to make it applicable to real fibers is based on the effect of fiber width on N_s'' and on the ratio N_s''/N_h''.

Consider a point along a scanning line. The probability that it is covered by a fiber is (6):

$$\frac{\pi\bar{\lambda}\bar{\omega}}{2(\bar{\lambda}+\bar{\omega})\bar{L}} \approx \frac{\pi\bar{\omega}}{2\bar{L}} \text{ (when } \bar{\lambda} \gg \bar{\omega})$$

The probability that the point is not covered is $\left(1-\pi\frac{\bar{\omega}}{2L}\right)$; the probability that it is not covered by N fibers is:

$$\left(1 - \frac{\pi\bar{\omega}}{2\bar{L}}\right)^N \approx \exp\left(-\frac{\pi\bar{\omega}N}{2\bar{L}}\right) = \exp\left(-\frac{N_f\bar{\alpha}}{A}\right) \tag{A10}$$

when $\gg 1$ $\frac{\pi}{2}\frac{\bar{\omega}}{L}$ (as in 2-D sheets) and fiber curl is neglected.

The total free length along a scanning line of length L is:

$$L \exp\left(-\frac{N_f\bar{\alpha}}{A}\right) \tag{A11}$$

It will be shown in the following section that the mean gap size, L/N, is not affected by fiber width (4). Dividing equation (A11) by L/N gives the mean number of gaps along a scanning line of length L:

$$\bar{n}_g = N\bar{r}\exp\left(-\frac{N_f\bar{\alpha}}{A}\right)$$

or for fibers of length $\bar{\lambda}$:

$$\bar{n}_g = \bar{c}\exp\left(-\frac{N_f\bar{\alpha}}{A}\right) = \bar{c}\exp\left(-\frac{\pi\bar{\omega}\bar{r}\bar{c}}{2\lambda}\right) \tag{7}$$

The above considerations obviously also apply to the number of polygon sides in a 2-D sheet so that:

$$N_s = N_s''\exp\left(-\frac{N_f\bar{\alpha}}{A}\right) \tag{A12}$$

The effect of fiber width on the ratio N_s''/N_h'' cannot be determined rigorously. However, as long as the fibers only cover a small fraction of the sheet, it can be assumed that:

$$N_s''/N_h'' = N_s/N_h = 4 \tag{10}$$

We have assumed throughout that fiber width has a negligible effect on N_c (at low values of N/L), and obviously $N'' = N_f$. Substituting equations (A12) and (10), and $N'' = N_f$ and $N_c'' = N_c$ into equation (A9) gives:

$$N_h = (N_c - N_f)\exp\left(-\frac{N_f\bar{\alpha}}{A}\right) \tag{9}$$

Dividing equation (9) into the open area of a 2-D sheet, $Ap(0) = A\exp\left(-\frac{N_f\bar{\alpha}}{A}\right)$ gives:

$$\bar{a}_{hh} = \frac{A}{N_c - N_f}$$

***Equations* (3) *and* (6). (4)**

The following considerations show that the size of the free fiber length is unaffected by fiber width, or that:

$$\frac{L''}{N''} = \frac{L}{N} = \bar{g} \tag{6}$$

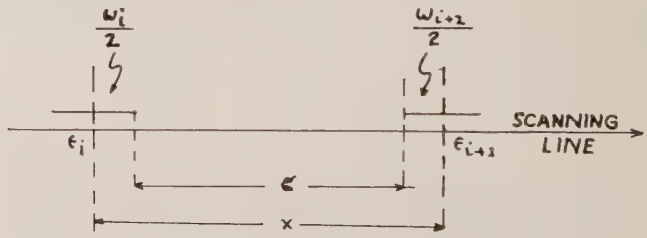

Fig. 18

Let ϵ_i and ϵ_{i+1} be two of the N intersections between fiber axes and the scanning line L (see Fig. 18). The probability that the distance between the axes has a value between x and $x + dx$ is:

$$p(x) = \frac{N}{\bar{L}}\exp\left(-\frac{N}{\bar{L}}x\right)dx \tag{3}$$

Place at each intersection, ϵ_i and ϵ_{i+1} a fiber of width ω_i and ω_{i+1} to create a gap of size g between the points ϵ_i and $\epsilon_i + 1$. The distribution of x is known. The distribution of g can be found provided that $g = x - \bar{\omega} > 0$ where $\bar{\omega} = (\bar{\omega}_i/2) + (\bar{\omega}_{i+1}/2)$. Under these conditions:

$$p\ (g \text{ between } g \text{ and } g + dg) =$$
$$p\ (x \text{ between } \bar{\omega} + g \text{ and } \bar{\omega} + g + dg, \text{ provided that } x > \bar{\omega}) =$$
$$\frac{p\ (x \text{ between } \bar{\omega} + g \text{ and } \bar{\omega} + g + dg \text{ and } x > \bar{\omega})}{p\ (x > \bar{\omega})} =$$
$$\frac{\frac{N}{L} \exp\left[-\frac{N}{L}\left(\bar{\omega} + g\right)\right]}{\int_{\omega}^{\infty} \frac{N}{L} \exp\left(-\frac{N}{L} t\right) dt} = \frac{N}{L} \exp\left(-\frac{N}{L} g\right) dg \quad (3)$$

Thus the distributions of g and x are alike and their means are equal to each other and equal to L/N.

APPENDIX II

DERIVATION OF EQUATIONS (15), (21), and (29)

***Equation* (15).** *(4)*

Consider a set S_1 of equidistant parallel lines which are a perpendicular distance of l_1 apart (see Fig. 19). Place a straight fiber of length λ on these lines so that the center of the fiber is chosen at random but the angle between the fiber and the parallel lines is θ. The mean number of lines which are crossed by the fiber is:

$$\bar{Z}_1\ (\theta) = \lambda \sin \theta / l_1$$

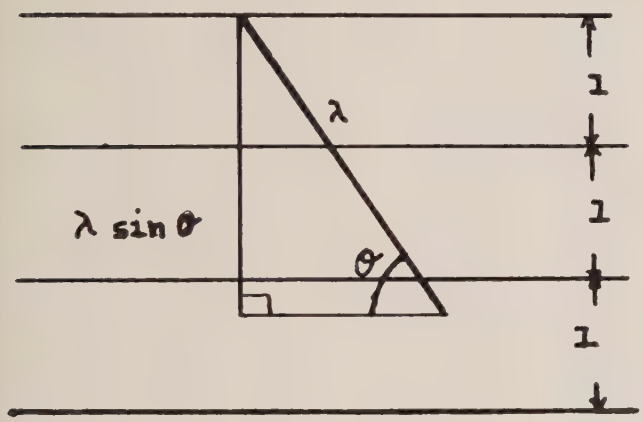

Fig. 19

If the fiber has random orientation, the mean number of crossed lines is:

$$\bar{Z}_1 = \int_0^{\pi} \frac{\lambda}{\pi l_1} |\sin \theta|\ d\theta = \frac{2\lambda}{\pi l_1}$$

If a second set S_2 of equidistant parallel lines, a distance of l_2 apart, is placed on top of and at any angle to S_1, the mean number of lines in S_2 crossed by the same fiber is:

$$\bar{Z}_2 = \frac{2\lambda}{\pi l_2}$$

The mean total number of lines crossed in both sets is:

$$\bar{Z} = \bar{Z}_1 + \bar{Z}_2 = \frac{2\lambda}{\pi}\left(\frac{1}{l_1} + \frac{1}{l_2}\right) \quad (A13)$$

If two sets S_1 and S_2 form a grid of squares of side length l(i.e., $l_1 = l_2 = l$), equation (A13) reduces to:

$$\bar{Z} = \frac{4\lambda}{\pi l}$$

However, a fiber intersecting $\bar{Z}$ lines is divided into $\bar{k} = \bar{Z} + 1$ segments. Therefore, the number of segments into which a fiber of length λ—placed at random on a grid of squares of side length l—is divided is:

$$\bar{k} = \frac{4\lambda}{\pi l} + 1 \quad (13a)$$

k is also the number of squares in which the fiber lies. If $l = 1$ mm. and λ has a distribution with a mean $\bar{\lambda}$:

$$\bar{k} = \frac{4\bar{\lambda}}{\pi} + 1 \quad (15)$$

(The distribution of Z is discussed at some length in reference *(6)*.)

It was mentioned previously that the fiber segments are either chords or ends. The number of chords (N_{ch}) and the number of ends (N_e) formed by a large number of fibers deposited at random on a grid of squares can easily be calculated. Each fiber has two ends and, hence, forms ($\bar{k} - 2$) chords. Thus, the ratio of the number of chords to the number of ends (taking into account fiber curl) is:

$$\frac{N_{ch}}{N_e} = \frac{4\bar{\lambda} + \pi(1 - 2\bar{\tau}^2)}{2\pi\bar{\tau}^2} \quad (A14)$$

The ratio of the mean chord length, $\bar{\lambda}_{ch}$, to the mean end length, $\bar{\lambda}_e$, has been derived. Deltheil *(6)* has shown that for straight chords, $\bar{\lambda}_{ch} = \pi a/4$ which, for a square of side length 1 mm., reduces to:

$$\bar{\lambda}_{ch} = \pi/4 \quad (A15a)$$

For curled chords,

$$\bar{\lambda}_{ch} = \pi\bar{\tau}/4 \quad (A15)$$

The same expression is obtained from $\bar{\lambda}_{ch} = \bar{\lambda}\ \bar{\tau}/\bar{k}$ and equation (15) when $\bar{\lambda} \to \infty$.

The mean length of straight line ends $\bar{\lambda}_e$, is given by *(4)*,

$$\bar{\lambda}_e = \overline{\lambda_{ch}^2}/2\bar{\lambda}_{ch} \quad (A16)$$

where:

$$\overline{\lambda_{ch}^2} = l^2(\ln(1 + \sqrt{2}) + 1/3(1 - \sqrt{2})$$

When $l = 1$ mm.:

$$\overline{\lambda_{ch}^2} = 0.745 \text{ sq. mm.} \quad (A17)$$

Combining equations (A15a), (A16), and (A17) gives:

$$\bar{\lambda}_{ch}/\bar{\lambda}_e = 1.67 \quad (A18)$$

(It is not necessary to take $\bar{\tau}$ into account when considering the ratio of chord and end lengths.)

***Equation* (21)**

Equation (5) gives the mean number of crossings per sq. mm. when both sides of the equation are multiplied by a/A.

$$\frac{a}{A}\frac{N_f^2\ \bar{\lambda}^2}{\pi\ \bar{\tau}^2} = 1/2 P' n_{seg}(n_{seg} - 1) \quad (A19)$$

Substituting ($aN_f/A = \bar{n}_f$), and equations (15) and (18) into equation (A19) gives:

$$P' = \frac{\pi\bar{n}_f\bar{\tau}^2(\bar{k} - 1)^2}{(8\bar{n}_f\bar{k} - \bar{\tau}^2)\bar{k}} \quad (21)$$

Deltheil (*6*) has derived the following expression for the probability of the intersection of two chords in a convex area:

$$P = \frac{2\pi a}{U^2} \qquad \text{(A20)}$$

where U is the perimeter of the convex area. For a square of unit side length, equation (A20) reduces to $P' = \pi/8$ as does equation (21) for long straight lines ($\tau = 1, k \gg 1$).

***Equation* (29). (*4*)**

Consider two arbitrary figures of area α_1 and α_2 and perimeters U_1 and U_2 respectively (see Fig. 20). Place both areas at random onto a large area A. The mean common area of α_1 and α_2, α_{12} is the product

$$\alpha_{12} = (\alpha_{12}|\text{int.}) \cdot P(\text{int.}) \qquad \text{(A21)}$$

where $(\alpha_{12}|\text{int.})$ is the mean common area provided the figures intersect and P (int.) is the probability that an intersection occurs. In the present aplication, α_1 and α_2 are the projected areas of fibers and $(\alpha_{12}|\text{int.})$ is the mean area of a fiber crossing.

P (int.) and (α_{12}) can be evaluated. Mack (*7*) has shown that:

$$P\,(\text{int.}) = \frac{\alpha_1 + \alpha_2 + U_1U_2/2\pi}{A} \qquad \text{(A22)}$$

α_{12} is found as follows:

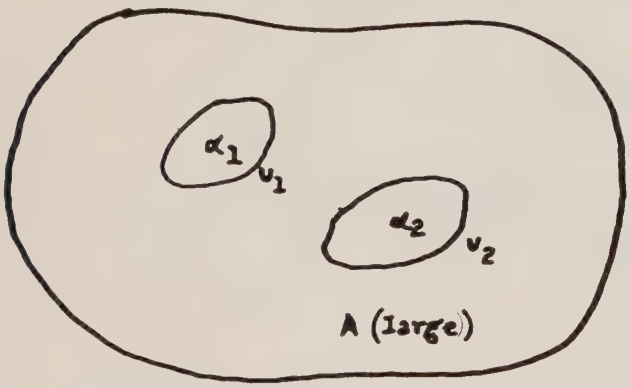

Fig. 20

Consider a point Q in A. The probability that Q is covered by both α_1 and α_2 is:

$$\frac{\alpha_1}{A} \cdot \frac{\alpha_2}{A} = \frac{\alpha_1\alpha_2}{A^2}$$

Thus,

$$\alpha_{12} = \left(\frac{\alpha_1\alpha_2}{A^2}\right) A = \frac{\alpha_1\alpha_2}{A} \qquad \text{(A23)}$$

Substituting equations (A22) and (A23) into (A21) gives:

$$(\alpha_{12}|\text{int.}) = \bar{\alpha}_c = \frac{\alpha_1\,\alpha_2}{\alpha_1 + \alpha_2 + U_1U_2/2\pi} \qquad \text{(29a)}$$

For fibers, $\bar{\alpha}_1 = \bar{\alpha}_2 = \bar{\lambda}\,\bar{\omega}$, $U_1 = U_2 = 2(\bar{\lambda} + \bar{\omega})$, and $\bar{\lambda} \gg \bar{\omega}$
Thus

$$\bar{\alpha}_c = \frac{\pi}{2}\,\bar{\omega}^2 \qquad \text{(29)}$$

APPENDIX III

SAMPLE CALCULATIONS

The procedure of transforming a Poisson distribution (equation 2) to a distribution of means is described below in detail; the example given is that of the distribution of fiber crossings per sq. mm. for sheet no. 3, equation (20). The terms of this equation, $\bar{k}$, P', and $\bar{n}_{seg}$, must be evaluated from the independent fiber properties (see Table II) before the transformation can be made.

$\bar{k}$ is evaluated directly from $\bar{\lambda}$ by equation (15). Knowing $\bar{k}$, $\bar{n}_{seg}$ is calculated from equation (18), and P' from equation (21). For sheet no. 3, $\bar{k} = 3.26$, $\bar{n}_{seg} = 14.3$, and $P' = 0.244$ (see Table III).

The key of the procedure is that the fraction of the 1-sq. mm. squares containing n_c crossings is equal to the fraction containing n_{seg} segments where n_c and n_{seg} are related by equation (19). The frequency distribution of n_{seg} is Poisson; thus the frequency of squares containing from 0 to 30 fiber segments is obtained directly from a table of Poisson values (*8*) with a mean of 14.3. The number of crossings for each value of n_{seg} is calculated from equation (19); $n_r = (0.244/2)\ n_{seg}(n_{seg}-1)$.

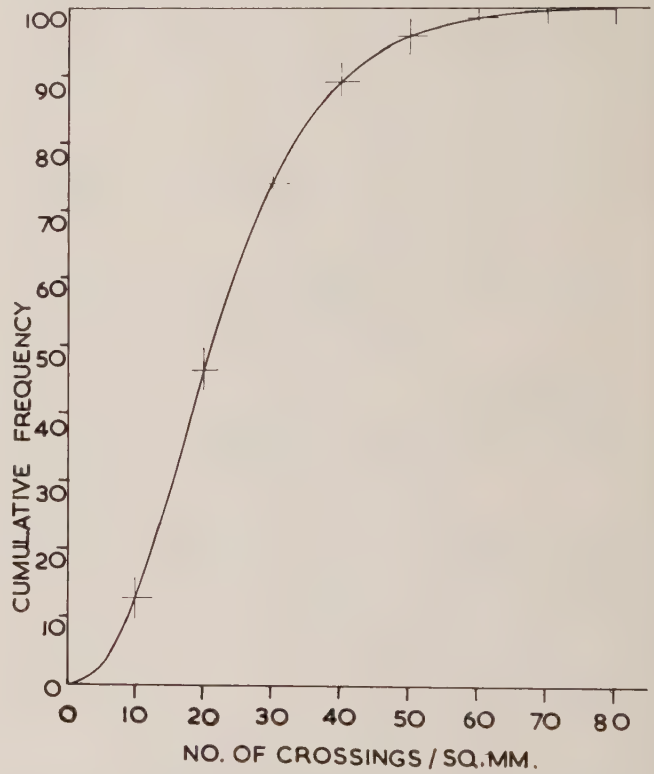

Fig. 21. Cumulative frequency curve of fiber crossings per sq. mm.
Sheet no. 3

As n_c and n_{seg} are not linearly related, the class widths of n_c are not equal for the frequencies obtained directly from the Poisson tables. The frequencies of equal class widths of n_c are obtained in the usual manner from the cumulative frequency curve of n_c (see Fig. 21).

RECEIVED May 16, 1960.
We would like to express our sincere appreciation to Mr. R. E. Miles of Cambridge University for his assistance with the mathematical parts of the investigation; to Mr. H. Marchand and Mr. C. Morgan for their assistance in the experimental work; to the Tropical Products Institute, London, in particular to Mr. A. Chittenden, for the use of their pulping equipment; and to the Board of Directors of Wiggins Teape & Co., Ltd., in particular Dr. H. F. Rance, for permission to publish the results of this investigation.

Heat Transfer and Water Removal in Cylinder Drying

I. Unfelted Cylinders

A. H. NISSAN and D. HANSEN

In earlier papers (*1*) a theory was presented for describing the transfer of heat and evaporation of water on a cylinder drier. Approximate solutions for the equations were also presented, together with an example of their application to some calculations on an industrial machine. Exact numerical solutions for the theoretical equations have now been obtained and verified by comparison with experimental measurements. The results of these experiments have also allowed a detailed look at the mechanisms of water removal, and the factors controlling transfer of heat on a cylinder drier.

A NUMBER of papers have been published recently reporting the results of fundamental experimental investigations of the cylinder drying process. Attwood and Smith (*2*) simulated the process of drying on many cylinders in series, and in this way were able to study the effects of changing machine conditions; such as felt tension, contact time, and relative air velocity. Dreshfield and Han (*3, 4*) employed a beta-ray transmission technique to study the movement of moisture in a sheet while drying. Han and Ulmanen (*5*) extended this work, measuring temperatures in a sheet as well as moisture content. Brauns and Janson (*6*) and Janson and Nordgren (*7*) have reported the results of extensive experimental study of heat transfer on Yankee drier. In their experiments they measured temperatures of the sheet, felt, and cylinder shell for a variety of operating and furnish conditions.

These investigations have all contributed much to gaining an understanding of the mechanisms which control the cylinder drying process. This paper presents the results of an attempt at precise quantitative description of some of these mechanisms; particularly the heat transfer in the sheet.

THEORY

If we divide a drier into phases, according to whether the sheet is on the cylinder or in the draws, and whether it is covered with a felt or exposed at the outer surface, (see Fig. 1) it is then possible to describe in general terms, by a differential equation and appropriate boundary conditions, the heat transfer and evaporation of water in each phase. The same differential equation applies throughout:

$$\frac{\partial^2 t}{\partial x^2} = \frac{1}{\alpha}\frac{\partial t}{\partial \theta}$$

where

t = temperature
x = distance through thickness of the sheet
α = thermal diffusivity
θ = time

Boundary conditions to be observed in solving the equation will be different for each phase. These boundary conditions are concerned with the initial temperature distribution, and with the heat flux at the surfaces of the sheet. These heat fluxes are in turn related to evaporation occurring at the surfaces. Owing primarily to the complex relation between temperature and vapor pressure (which is the driving force for evaporation) the resulting boundary value problem is not readily solved by the usual analytical techniques. However, by making a series of assumptions approximate analytical solutions may be obtained. This was done in earlier papers (*1*) where the approximate solutions were demonstrated with some calculations of temperatues and evaporation rates on two industrial machines.

The approximate solutions, however, are inadequate to describe the precise temperature behavior at internal points in a sheet. Hence, exact numerical solutions were obtained using a high-speed digital computer. The details of setting up the mathematical problem and obtaining numerical solutions have been reported by Hansen (*8*) and are in press (*9*).

An example of such a numerical solution for phase I is given in Fig. 2 (calcd. temperatures). The parameters listed in Fig. 2 are dimensionless groups, found

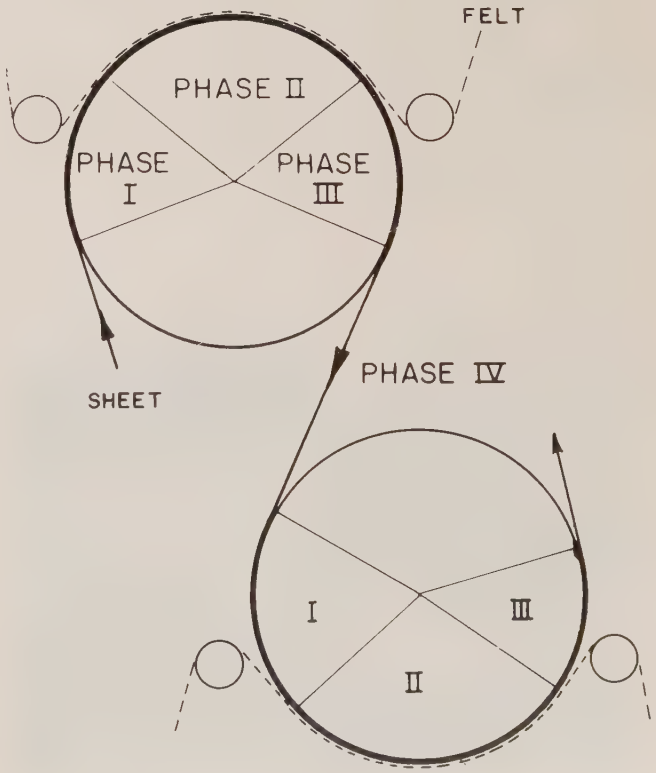

Fig. 1. Phases on drying cylinder

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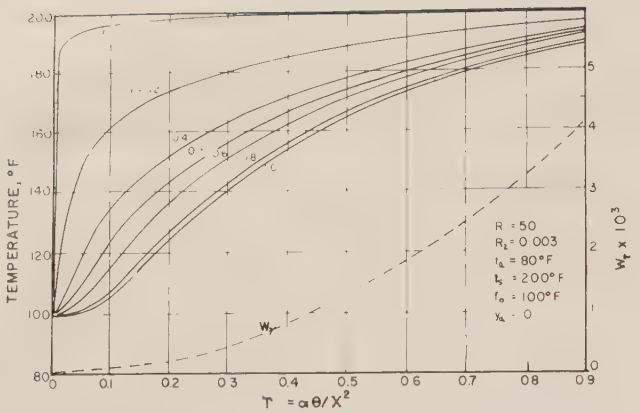

Fig. 2. Example of numerical solution for phase I

to be convenient in the calculations, and are defined as follows:

$R_1 = \frac{H_1 X}{k}$ dimensionless heat transfer coefficient between inner sheet surface and cylinder surface

$R_2 = \frac{H_2 X}{k}$ dimensionless heat transfer coefficient between outer sheet surface and air

$r = \frac{x}{X}$ dimensionless distance

$\tau = \frac{\alpha\theta}{X^2}$ dimensionless time

$W_\tau = \frac{\alpha\lambda W}{X k t_b}$ dimensionless quantity of water evaporated

where

H_1 = heat transfer coefficient at inner sheet surface, B.t.u./hr. ft.² °F.
H_2 = heat transfer coefficient at outer sheet surface, B.t.u./hr. ft.² °F.
X = total thickness of sheet, ft.
k = sheet thermal conductivity, B.t.u./hr. ft. °F.
x = distance through thickness of sheet, ft.
α = thermal diffusivity, ft.²/hr.
θ = time, hr.
λ = latent heat of evaporation, B.t.u./lb.
ω = quantity evaporated, lb.
t_b = boiling point of water, °R. (°F. + 460)

EXPERIMENTAL MEASUREMENTS

Measurements of temperatures at internal points in a sheet, while on a heated cylinder, were made using an experimental drier specifically designed for this purpose. A picture of the drier is given in Fig. 3. The following dimensions apply to the drying cylinder:

diameter	12.7 in.
shell thickness	0.375 in.
width	14 in.

Heat was supplied to the cylinder through an elec-

Fig. 3

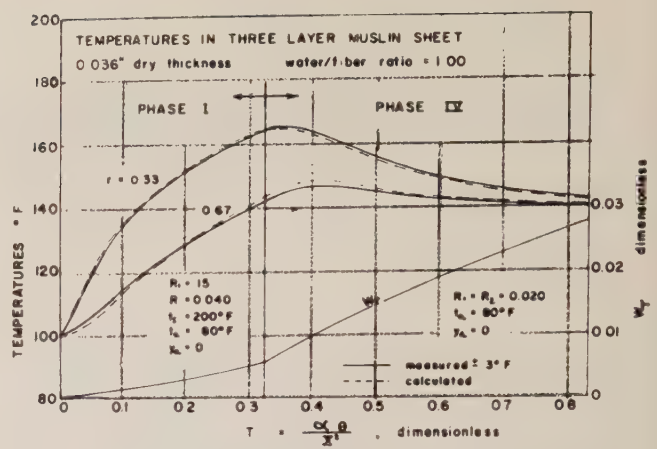

Fig. 4. Comparison of measured and calculated temperatures

tric immersion coil, which boiled the water inside the cylinder. The machine was belt driven, and variation of pulley combinations permitted operation from 5 to 75 r.p.m. A blower, forcing air through a duct over cylinder, permitted independent control of the relative speed between sheet and air.

The sample sheets passed over the cylinder, between reels on either side. Overhead weights attached to these reels maintained sheet tension at a constant value.

Temperatures of the cylinder surface were sensed and recorded from iron-constantan thermocouples soldered to the cylinder surface. Leads from these couples passed through small drill holes in the shell, into the interior of the cylinder. They were connected to a recording potentiometer via slip rings on the cylinder shaft.

The sheet samples were prepared from muslin cloth, stitched three together to form a composite about 0.036 in. in total thickness (dry). Thermocouples (copper-constantan) prepared from 1-mill wire were placed between these layers to record temperatures in the sheet. (10- and 5-mil wire was unsatisfactory; as the mass of thermocouples prepared from them was found to cause low readings of the transient temperature rises.) Leads from these thermocouples were connected to a d.c. amplifier and then to a Sanborn "Twin-Viso" recording galvanometer.

RESULTS AND DISCUSSION

Temperature Studies

In Figs. 4 and 5 are presented the results of experi-

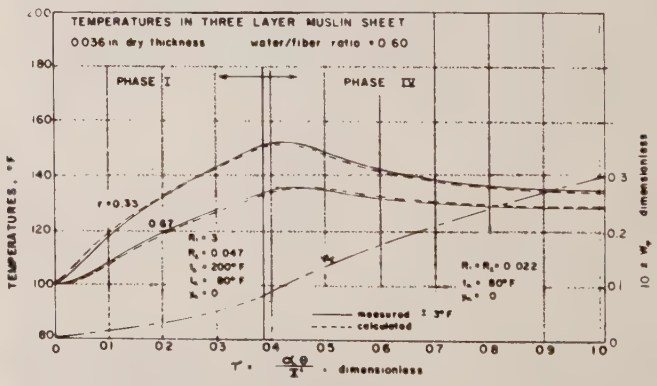

Fig. 5. Comparison of measured and calculated temperatures

ments measuring the temperature at two depths in the sheet as it passed over the cylinder. Comparison of the curves for measured and calculated temperatures demonstrates the excellent agreement found between theory and experiment. It should be noted that the curves for measured temperatures represent an average for a series of experiments. These results are for four experiments, each of which consisted of about 15 passes of sheet over cylinder, the sheet becoming progressively drier with each pass. Since two temperature recordings were obtained per pass, there were actually a total of about 120 temperature curve measurements. This averaging of results was found to be necessary because differences in temperature measurement were observed between different runs, and even between two measurements in the same run. These differences amounted usually to a few degrees but in a few runs were as much as 15°F. It is believed that these differences may be due to differences in contact between sheet and cylinder from point to point, caused by uneven wetting of cylinder surface and nonuniform distribution of sheet pressure. These factors may be more uniform on an industrial machine than on the experimental apparatus, and one might expect smaller variations to occur. Several conclusions on sheet temperatures can be drawn from the results of these experiments:

1. Cylinder surface temperature remains essentially constant. The calculated temperatures with which the experimental results were correlated, were based on constant surface temperature for the cylinder. Use of constant surface temperature in this case was based on actual measurements, which showed that the cylinder surface temperature did not change by more than 3°F. while the cylinder surface was in contact with the sheet. This observation is in agreement with the findings of several other researchers who have made similar measurements.

2. While in contact with the cylinder, the sheet behaves, in regard to transfer of heat, like a solid. Only with very wet sheets (water:fiber = 1.2) was there any evidence of convection heat transfer within the sheet. In these very wet sheets the measured temperatures were a few degrees higher than indicated by conduction calculations.

3. Temperatures drop through the thickness of the sheet is quite large. In these experiments, using a sheet 0.036 in. thick, temperature differences between the inner and outer surfaces were observed which were of the order of 40 to 60°F.; depending on time of contact, and the moisture content. Similar experiments with a sheet 0.024 in. thick showed equal temperature differences between surfaces, and the same would be expected with even thinner sheets. This is so, because, for the time the sheet is on the cylinder, the heat transfer is controlled by transient phenomena, and the steady-state temperature distribution is not established. In these experiments the sheet always came onto the cylinder at 100°F. For sheets at a higher temperature coming onto the cylinder, a somewhat smaller temperature drop through the thickness would be expected.

4. Heat transfer resistance between cylinder surface and sheet is small but not negligible. Some values of the heat transfer coefficient between cylinder surface and sheet, as determined from the analysis of the experiments, are given in the following table.

Moisture content, lb. water/lb. fiber	*Heat transfer, coeff. H_1, (B.t.u./hr. ft.² °F.)*
1.2	∞
1.0	1700
0.8	450
0.6	290

These coefficients pertain to the film resistance between cylinder shell and sheet. They do not include resistance within, or in, the cylinder; or in the sheet itself. It is seen that these coefficients account for a relatively small part of the overall resistance on a drier shell which has been estimated, in terms of heat transfer coefficients, from 30 to 75 B.t.u./hr. ft.² °F. Still, while this resistance is small, it is, together with sheet thickness and conductivity, the controlling factor in the transient heating of the sheet. This may be seen from a comparison of the temperature plots in Fig. 4 (H_1 = 1700) and Fig. 5 (H_1 = 290 B.t.u./hr. ft.² °F.). Although this coefficient is controlling for the transient flow of heat into the sheet, this does not suggest that other heat transfer resistances on a drier (steam film, and shell conductivity) are unimportant. These control the flow of heat to the cylinder surface, and hence the surface temperature of the cylinder is determined by the heat flow through these resistances, as well as the heat removal by transient conduction into the sheet.

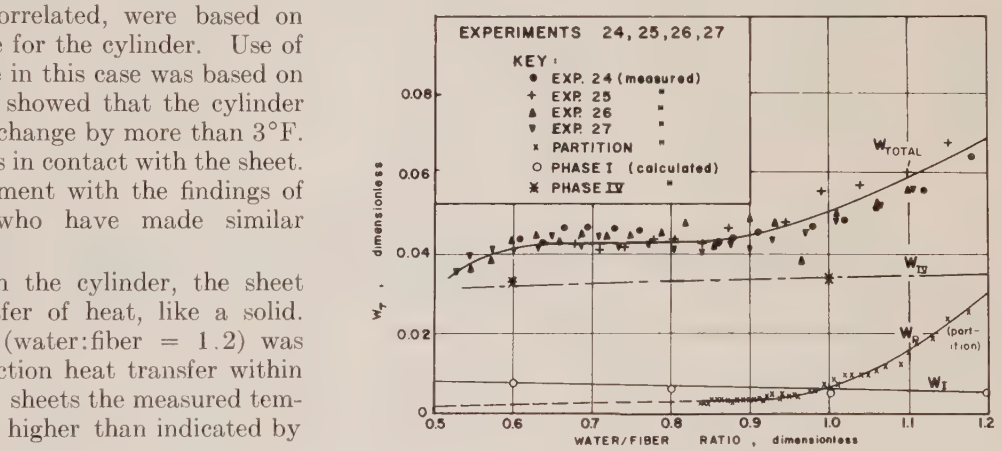

Fig. 6. Moisture losses, 2

Two limitations on the results of these experiments should be noted as they affect the general conclusions: (1) the cylinder temperature used (200°F.) was below the boiling point of water; at above-boiling temperatures evaporation within the sheet could cause grossly different behavior. (2) The tension on the sheet was constant throughout the experiments (1.11 lb./in. ≈ 0.167 p.s.i. pressure). Larger or smaller tension values would be expected to exert a corresponding influence on the heat transfer resistance between cylinder and sheet.

Water Removal

As a part of the same experiments in which the temperature measurements were made, measurements were also made of the removal of water. The results of these measurements are presented in Fig. 6. Four curves, all independently determined, are given in Fig. 6 for removal of water by three mechanisms. One is the

amount calculated to have evaporated from the outer surface in phase I; this calculation was a part of the numerical solution for evaluating temperatures. A second curve represents water removed by partition between cylinder and sheet; this was determined from a series of experiments where the sheet was passed over a cold cylinder. Another curve represents water evaporated from the sheet between cylinder and takeup reels (phase IV); this quantity was calculated as a part of the numerical solution for temperatures in phase IV. The uppermost curve represents the total water removed, and was measured from weight losses during the experiments for temperature measurement. It is seen from this graph that the consistency of determinations is good. The sum of water removed by each of the three mechanisms is equal to 80 to 85% of the measured total. The difference, at least in part, may be attributed to losses incurred in handling samples during the experiments.

It is seen that water removed by partition was appreciable, and was, in these runs, of the same order as that evaporated in phase I. It is suspected that the partition determinations, on a cold cylinder, may even have given a low estimate of the partition which actually occurred during the drying experiments on a hot cylinder.

The major portion of water removed, in these experiments, was by evaporation in phase IV. (40 to 50% of total). The length of phase IV in the experimental drying tests was about 50% greater than phase I (2.5 and 1.7 sec. respectively). Hence under the conditions of these experiments, relatively little evaporation occurred in phase I, but in phase IV, a greater evaporation occurred using the heat absorbed in phase I.

CONCLUSIONS

It is concluded that the theory is adequate and accurate for calculation of heat transfer and evaporation, and for calculation of temperature distributions in the sheet with respect to both space and time on a cylinder drier. This has been experimentally demonstrated for phases I, III, and IV. Further detailed study is now being done on phase II to elucidate the complicated influence of felts. Further work is also being done on partition of water between a wet sheet and a hot cylinder.

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Received Mar. 31, 1960. Presented at the 45th Annual Meeting of the Technical Association of the Pulp and Paper Industry, held in New York, N. Y., Feb. 22–25, 1960.

Studies on the Barks of the Family Salicaceae

III. The Alkaline Hydrolysis of Barks of Several Species of the Genus Populus

IRWIN A. PEARL, DONALD L. BEYER, DAWN LASKOWSKI, and DONALD WHITNEY

The barks of several *Populus* species important to the pulp and paper industry were subjected to alkaline hydrolysis. Barks studied included smooth and green and dark and furrowed outer barks and inner bark. The alkaline hydrolyzates were acidified and extracted with ether. The ether extracts were analyzed qualitatively by paper chromatography and quantitatively by paper chromatographic and spectrophotometric procedures for phenolic materials. Phenolic acids were the chief product of alkaline hydrolysis. In some cases, *p*-coumaric acid was the chief product of alkaline hydrolysis. In other cases, *p*-hydroxybenzoic acid, syringic acid, or ferulic acid was the chief product. All species tested yielded vanillin, syringaldehyde, *p*-hydroxybenzaldehyde, acetovanillone, acetosyringone, vanillic acid, syringic acid, ferulic acid, *p*-hydroxybenzoic acid, and *p*-coumaric acid upon alkaline hydrolysis. The presence of salicyl alcohol was indicated in all hydrolyzates, but the compound was not isolated for positive identification and estimation. The presence of a number of unidentified nonphenolic compounds was indicated by qualitative paper chromatography.

In a recent paper on the products of alkaline hydrolysis of various portions of the aspen tree (*1*) it was found that the chief product of alkaline hydrolysis of *Populus tremuloides* bark was *p*-coumaric acid whereas the chief product from similar hydrolysis of other portions of *P. tremuloides* was *p*-hydroxybenzoic acid. This finding led to more extensive investigation of the alkaline hydrolysis procedure as applied to *P. tremuloides* bark and to the barks of other *Populus* species. The present paper reports results obtained on the investigation of the barks of several *Populus* species of importance to the pulp and paper industry. This paper includes some studies on types of bark for particular species.

EXPERIMENTAL

Starting Materials

Populus tremuloides (quaking aspen) bark was ob-

Irwin A. Pearl, Senior Research Associate and Chief; Donald L. Beyer, Research Aide; Dawn Laskowski and Donald Whitney, Laboratory Assistants, Lignin Chemistry Group, The Institute of Paper Chemistry, Appleton, Wis.

Table I. Chromatographic Data for Hydrolyzate Extractives in Butanol-Aqueous Ammonia

Butanol-2% aqueous ammonia R_f[a]

	0.00	0.02	0.08[b]	0.10[c]	0.12[d]	0.14[e]	0.16	0.27	0.33[f]	0.44[g]	0.50[h]	0.60[i]	0.69	0.72	0.88
P. tremuloides[j]	x	x	x	x	x	x	..	x	x	x	x	x	..	..	x
P. grandidentata[j]	x	..	x	x	x	x	..	..	x	x	x	x	..	..	x
P. tacamahaca[j]	x	..	x	x	x	x	..	..	x	x	x	x	..	x	..
P. deltoides[j]	x	..	x	x	x	x	x	..	x	x	x	x	..	..	x
P. deltoides[k]	x	x	x	x	x	x	x	..	x	x	x	x	..	..	x
P. trichocarpa[j]	x	x	x	x	x	x	..	..	x	x	x	x	..	..	x
P. trichocarpa[k]	x	x	x	x	x	x	..	..	x	x	x	x	..	..	x
P. heterophylla[kl]	x	..	x	x	x	x	..	x	x	x	x	x	..	..	x
P. heterophylla[m]	x	..	x	x	x	x	x	x	x	x	x	x	x	..	x

[a] Rf determined by means of bis-diazotized benzidine spray. [b] Syringic acid. [c] Vanillic acid. [d] *p*-Hydroxybenzoic acid and ferulic acid. [e] *p*-Coumaric acid. [f] Syringaldehyde. [g] Vanillin. [h] Acetosyringone. [i] Acetovanillone. [j] Green and smooth bark. [k] Dark and furrowed bark. [l] Outer bark. [m] Inner bark.

tained from a tree cut in late May in Upper Michigan. The bark was smooth and green. Similarly, smooth green barks were obtained from *P. grandidentata* (bigtooth aspen) and *P. tacamahaca* (balsam poplar) trees cut in Upper Michigan in July and August, respectively.

P. deltoides (cottonwood) barks were taken from a tree felled in Wisconsin in July. Samples of smooth green bark and furrowed dark bark were obtained from this tree.

P. trichocarpa (northern black cottonwood) barks were obtained from the Snohomish Valley in Washington in September. Both smooth green and dark furrowed barks were obtained.

Thick reddish-brown deeply fissured bark of *P. heterophylla* (swamp cottonwood) was obtained from Mississippi in January. The thick bark was separated into an almost white inner bark and the reddish-brown outer bark.

All barks were allowed to air dry and were then reduced in a Wiley mill to pass a 20-mesh sieve. Heavy barks were chipped before air-drying.

Hydrolysis and Analysis Procedures

All alkaline hydrolyses were made on the finely divided barks as described earlier (*2*). Alkaline hydrolyzates were acidified with dilute sulfuric acid and exhaustively extracted with ether. Ether extracts were analyzed for solids content and were chromatographed qualitatively on paper and developed at 20° in butanol saturated with 2% aqueous ammonia and in 10:3:3 butanol-pyridine-water systems. Spots were located by means of bis-diazotized benzidine, diazotized *p*-nitroaniline, 2,4-dinitrophenylhydrazine, and Mäule spray reagents and by examination under ultraviolet light. Qualitative chromatographic data for these two developers are given in Tables I and II. Because these two developing systems do not separate satisfactorily vanillic, ferulic, *p*-hydroxybenzoic, and *p*-coumaric acids (*2*) and vanillin and *p*-hydroxybenzaldehyde (*3*), the data of Tables I and II have been amplified with data from benzene saturated with formic acid and 6:1:1 *n*-heptane-*n*-butyl ether-water systems. Where found, vanillin, syringaldehyde, *p*-hydroxybenzaldehyde, acetovanillone, acetosyringone, vanillic acid, syringic acid, *p*-hydroxybenzoic acid, ferulic acid, and *p*-coumaric acid were determined quantitatively by paper chromatographic and spectrophotometric procedures described previously (*2*, *3*, *4*). Quantitative data for these compounds are given in Table III along with yields of total ether extracts obtained upon alkaline hydrolysis of the bark samples.

Table II. Chromatographic Data for Hydrolyzate Extractives in 10:3:3 Butanol-Pyridine-Water

10:3:3 Butanol-pyridine-water R_f[a]

	0.00	0.02	0.04	0.06	0.09	0.16	0.18	0.27	0.33[b]	0.44[c]	0.56[d]	0.70	0.78[e]	0.84[f]
P. tremuloides[g]	x	x	..	..	x	x	..	..	x	x	x	x	x	x
P. grandidentata[g]	x	..	x	..	x	..	x	x	x	x	x	..	x	x
P. tacamahaca[g]	x	..	x	x	..	x	..	..	x	x	x	..	x	x
P. deltoides[g]	x	..	x	..	x	..	x	x	x	x	x	..	x	x
P. deltoides[h]	x	..	..	..	x	..	..	x	x	x	x	..	x	x
P. trichocarpa[g]	x	..	..	..	..	..	x	..	x	x	x	x	x	x
P. trichocarpa[h]	x	..	x	..	..	..	x	..	x	x	x	x	x	x
P. heterophylla[hi]	x	..	x	..	x	..	x	x	x	x	x	..	x	x
P. heterophylla[j]	x	..	..	..	x	..	x	x	x	x	x	..	x	x

[a] Rf determined by means of bis-diazotized benzidine spray. [b] Syringic acid. [c] Vanillic acid and ferulic acid. [d] *p*-Hydroxybenzoic acid and *p*-coumaric acid. [e] Syringaldehyde and acetosyringone. [f] Vanillin and acetovanillone. [g] Green and smooth bark. [h] Dark and furrowed bark. [i] Outer bark. [j] Inner bark.

Table III. Alkaline Hydrolysis of Barks of Several *Populus* Species

	Ether extract, %[a]	Vanillin, %[b]	Syringaldehyde, %	*p*-Hydroxybenzaldehyde, %	Acetovanillone, %	Acetosyringone, %	Vanillic acid, %	Syringic acid, %	Ferulic acid, %	*p*-Hydroxybenzoic acid, %	*p*-Coumaric acid, %	Total, %
P. treumuloides[c]	8.6	0.3	0.2	0.6	0.2	0.2	1.0	0.7	1.6	1.2	8.5	14.5
P. grandidentata[c]	7.8	0.5	0.4	0.7	0.3	0.1	2.8	6.0	4.0	4.4	3.8	23.0
P. tacamahaca[c]	8.6	0.2	0.2	0.3	0.1	0.3	2.5	0.6	3.0	1.4	6.1	14.7
P. deltoides[c]	2.9	0.9	0.2	0.0	0.3	0.5	4.2	3.2	3.8	5.9	1.8	20.8
P. deltoides[d]	3.7	0.9	0.7	0.8	0.4	0.6	3.4	2.4	5.6	3.8	2.1	20.7
P. trichocarpa[c]	6.8	0.4	0.3	0.2	0.3	0.2	3.3	2.1	3.3	4.8	6.3	21.2
P. trichocarpa[d]	4.9	1.2	0.3	1.5	0.6	0.5	3.9	2.9	4.4	4.2	6.1	25.6
P. heterophylla[de]	4.3	0.8	1.1	0.6	0.7	0.2	4.6	1.8	4.1	13.1	1.6	28.6
P. heterophylla[f]	4.3	1.1	0.3	0.0	0.5	0.2	3.8	3.0	2.3	15.0	3.6	29.8

[a] The yield of ether extract is on the basis of ovendry bark dust. [b] The yields of vanillin and all other hydrolysis products are on the basis of the ether extract. [c] Green and smooth bark. [d] Dark and furrowed bark. [e] Outer bark. [f] Inner bark.

DISCUSSION OF RESULTS

Qualitative chromatography of the ether extractives after alkaline hydrolysis demonstrated that the barks of all *Populus* species examined yielded vanillin, syringaldehyde, acetovanillone, acetosyringone, vanillic acid, syringic acid, *p*-hydroxybenzoic acid, ferulic acid, and *p*-coumaric acid. In addition, all barks tested except *P. deltoides* and the inner bark of *P. heterophylla* yielded *p*-hydroxybenzaldehyde.

The spots noted in Table I at R_f's 0.00 and 0.02 and in Table II at R_f's below 0.38 were detected by means of the bis-diazotized benzidine spray, but were not detected by diazotized *p*-nitroaniline spray reagent. During the course of our paper chromatographic investigations of lignin oxidation mixtures and of wood and bark extractives, we have noted that diazotized *p*-nitroaniline will indicate the presence of only phenolic materials and usually by means of brightly colored spots. On the other hand, bis-diazotized benzidine has been found to indicate many compounds by rejection rather than by reaction so that the material appears as a sized spot on the sprayed paper. Thus, it appears that the spots under consideration are due to nonphenolic materials and are probably aliphatic acids. All other nonidentified spots noted in Tables I and II are also indicated by diazotized *p*-nitroaniline, demonstrating the presence of phenolic materials.

The two spots with the highest R_f values in the two solvent systems comprise unknown mixtures of materials which approach the solvent front and which cannot be separated by the developing systems employed. Except for the possible mixtures in these high R_f spots, the qualitative chromatograms demonstrate remarkable similarity of phenolic material content in the alkaline hydrolyzates of the barks of the genus *Populus*. Table II indicates a spot unique for *P. tremuloides* and *P. trichocarpa*, and Table I indicates several spots unique for one or two species. In all cases, these unknown phenolic spots appeared in only minor amounts. Their taxonomic significance has not been ascertained.

Because of the known existence of salicin, the glucoside of salicyl alcohol, in the barks of most of the genus *Populus* (*5*, *6*) and because of the demonstrated presence of salireposide, the benzoylated glucoside of gentisyl alcohol, in the bark of *P. tremuloides* (*7*), the occurrence of salicyl and gentisyl alcohols might be expected in the alkaline hydrolyzates of the barks of the present study. Pure salicyl and gentisyl alcohols have identical R_f values of 0.90 in the butanol-aqueous ammonia developer and 0.86 in the butanol-pyridine-water developer. In admixture the two alcohols would appear in the spots recorded with the highest R_f value in both Tables I and II.

Authentic salicin was subjected to alkaline hydrolysis under conditions similar to that employed for the barks. The hydrolysis mixture was acidified, cooled, and extracted with ether. The ether extract contained salicyl alcohol in 60% yield. Qualitative paper chromatograms sprayed with diazotized *p*-nitroaniline and with ferric chloride reagents gave spots similar to those obtained with the high R_f materials of the *Populus* bark hydrolyzates.

The quantitative data of Table III are somewhat more enlightening than the qualitative data of Tables I and II. The overall yield of ether extract was highest in the smooth green barks except for the very low yield in the case of *P. deltoides*. The three yields above 7.5% were from barks collected in the summer, but again, the low yielding *P. deltoides* was also collected in the summer.

The earlier finding of *p*-coumaric acid as the chief product of alkaline hydrolysis of *P. tremuloides* bark (*1*) was confirmed in the case of *P. tacamahaca* and in the case of *P. trichocarpa*. Other *Populus* barks gave hydrolyzates with entirely different quantitative distributions. Both smooth and furrowed *P. heterophylla* barks yielded *p*-hydroxybenzoic acid as the chief product of alkaline hydrolysis with only a relatively small amount of *p*-coumaric acid. *P. deltoides* smooth bark yielded *p*-hydroxybenzoic acid as the chief product and *p*-coumaric acid as only a minor hydrolysis product. The dark and furrowed bark of *P. deltoides* yielded ferulic acid as the main hydrolysis product and *p*-coumaric acid as only a minor product. In the case of *P. grandidentata* bark, syringic acid was the chief hydrolysis product and ferulic, *p*-hydroxybenzoic, and *p*-coumaric acids were obtained in essentially equal amounts. Thus, although the nature of the hydrolysis products of these members of the *Populus* genus are essentially similar, the distribution of the specific compounds is very specific and may have taxonomic significance. However, it should be noted again that the results reported in this study are still preliminary in nature and reflect experimental data from single specimens of individual species. Possible variations discussed earlier (*2*) apply to the results and discussions of this paper.

The relatively high yields of phenolic acids compared with the phenolic aldehydes and ketones indicates the presence of ester groups rather than hydrolysis of acyloin configurations as discussed previously (*8*).

It should be noted that in all instances the identified products of alkaline hydrolysis of these *Populus* species barks amounted to less than 30% of the ether-solubles leaving 70% or more of the ether-soluble compounds unaccounted for. Studies are now underway in an attempt to isolate and identify more of this unaccounted for material.

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Received April 4, 1960.

The authors wish to thank J. S. McKnight of the United States Department of Agriculture, Southern Forest Experiment Station at Stoneville, Miss., Dr. Rolland F., Sultze of Simpson Timber Co., Everett, Wash., and Dr. Phillip N. Joranson and Miss Barbara Reeder of The Institute of Paper Chemistry for their help in obtaining the barks employed in this study.

Dielectric Heating for Drying Wood Fiberboard

DAVID C. CARTER

Wood fiberboard can be dried faster in an existing conventional hot-air oven if dielectric heating is used. By installing the high-voltage plates inside the exit end of the existing drier, no additional floor space would be required. One-half inch board was dried by combined hot-air and dielectric heating to about 7% moisture content. By using dielectric heating for a 4-min. period, total drying time was reduced 15 to 20%. Dielectric-heated board had more even moisture distribution throughout its thickness, and a more constant final moisture content was achieved. The conventional humidification process after drying could possibly be eliminated. It is more costly to heat dielectrically than by hot air. However, it may be justified if an existing plant needs increased drying capacity and if no additional floor space is available for lengthening the existing hot-air drier.

Materials such as wood fiberboard, which are nonconductors of electricity, can be heated uniformly throughout their volumes by passing an alternating current through them at high frequencies and high voltages. This principle is now being used commercially in (1) the curing of foundry cores, glue lines, and filter paper; (2) the heating of chemical powders and plastics preheating; and (3) the drying of cellulose sponge, rayon cakes, and paper. A few units are used abroad to preheat hardboard prior to hot-flat pressing.

This method of uniform heating is called high-frequency, or dielectric heating. The amount of heat generated in a material at a given frequency, voltage, and length of time is proportional to two electrical properties of the material being heated—its power factor and its dielectric constant; hence, the name "dielectric heating."

Dielectric heating, although more expensive to install and operate than conventional hot-air heating, has been considered for the drying of wood fiberboard. Near the end of a conventional hot-air drying cycle the remaining moisture is in the center layer of the board. The dielectric heater applied at this time generates heat in this wet center layer and thus speeds up the drying process and causes more even moisture distribution. Little additional floor space would be required and drying capacity would be increased. This could justify the installation of a dielectric heater if the existing drier is a bottleneck for increased production rates.

The disadvantages of conventional hot-air heating as compared to dielectric heating are: (1) the middle thickness is dried last; (2) large floor areas are required; (3) in order to heat the board, the air and the oven components must also be heated.

Dielectric heating is sometimes used to control final moisture content from the drier. This paper reports results of an investigation made to determine the approximate costs and the capabilities of dielectric heating at the exit end of an existing hot-air drier.

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EXPERIMENTAL PROCEDURE

All experimental work was conducted on an RCA Model 15CH, 15-kw. output, 4000 to 8000-v., 13-megacycle dielectric heater. The high-voltage lead was connected to a flat steel plate, $^1/_8 \times 18 \times 18$ in., which was located above the board being tested, with a 1-in. air space between. The board rested upon a grounded metal structure. This structure was a flat metal grille for a portion of the tests and Coe drier rollers for the balance of the tests. The grille was used when surrounding air was at room temperature.

Wood fiberboard samples were 14×14 in. and $^1/_2$ in. dry thickness. Samples were dried for different periods of time in the circulating hot-air drier at 350°F. and then placed in the dielectric heater.

Air was circulated around the samples in order to carry away the steam that was coming from the boards. The circulating air was at room temperature for the first few sets of samples. Then the dielectric heating setup was placed inside the Coe drier with the boards resting on the rollers and the flat plate being placed with about a 1-in. air space between surfaces.

Moisture distribution through the thickness of the sheet was checked by cutting 1×1-in. square samples from the sample and slicing them into five equivalent thicknesses. These five layers were then weighed immediately, dried, re-weighed, and the moisture content computed, based on dry weight. Weights were to the nearest 0.0001 g.

Calculated power costs were figured, using a rate of \$3.60 per M pounds of water removed (based on \$0.01 per kw.-hr.). This figure was furnished by the manufacturers as being representative of several present field installations. This figure could not be checked in the laboratory and be representative of plant-scale conditions. Maintenance cost was assumed to be \$0.90 per hr.—again based on the experience of manufacturers. Most of this cost is in the replacing of power tubes. Capital cost was based on an installed cost of \$500 per kilowatt of output. For example, a 200-kw. unit would cost about \$100,000 installed at the present time.

DISCUSSION AND RESULTS

The first part of the investigation of dielectric heating was to place the high-voltage plate and board sample in circulating air at room temperature. A few seconds after the voltage was applied, steam was produced. As this steam came off the board, it would often condense on the heater plate and drip onto the board. This would often cause arcing, overload the heater generator, and throw out the circuit breaker. Increased air circulation of the room-temperature air would reduce

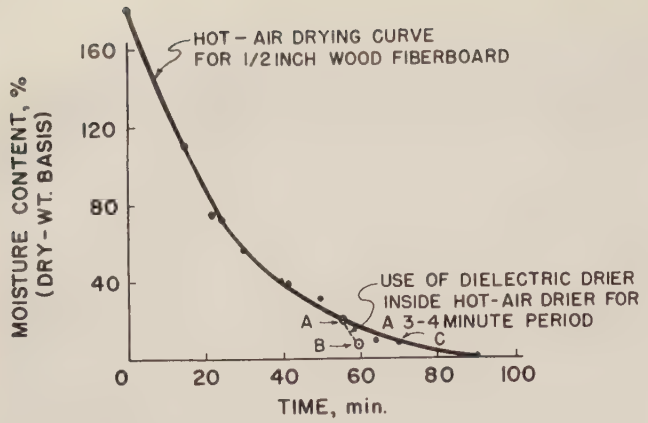

Fig. 1. Results of using dielectric drier at the end of the hot-air drier

Moisture content in middle layer of board thickness; A = 70%, B = 11%, C = 16%. See Fig. 2 and Table II for cost of dropping moisture content from 20 to 7%, as shown.

arcing. However, arcing was eliminated by placing the dielectric heating plate inside the laboratory Coe drier and using the lower rollers as the ground potential. This method of heating was used during the balance of the experiment.

When dielectric heating was applied near the end of the drying cycle, it was found that the total period required to obtain a 6 to 8% moisture content was reduced from 75 to 60 min. (see Fig. 1). The dielectric drier was used for a 3 to 4 min. period and was located inside the drier. Hence, no additional floor space was needed for installing the high-voltage plate. Moisture content in the center one-fifth layer was reduced from 70 to 11% during the 3 to 4 min. period of dielectric heating.

Moisture was more evenly distributed throughout the thickness of the sheet when dielectric heating was used (see Table I). When the average moisture content of a board was 8%, the middle layer was 11% moisture content if it had been heated dielectrically, but 16% if it had been heated with circulating hot air.

With even moisture distribution the boards may be ready for trimming and packaging as they emerge from the drier. Therefore, the customary humidification process would be eliminated, provided the boards met all physical property requirements for their intended end uses. Some boards may require drying to moisture-free condition in order to obtain desired moisture properties.

Effectiveness of dielectric heating was reduced as

Table I. Moisture Distribution Before and After Dielectric Heating

Moisture Distribution Through the Thickness of a 1/2-In. Wood Fiberboard after Dielectric Heating
(Per cent moisture content, dry weight basis)

Hot-air drying period, min. →	—30—		—38—		—56—		70
Dielectric heating following hot-air drying, min. →	0	5	0	5	0	4	0
Thickness layers							
Top	10	6	9	7	7	7	7
2nd	68	16	35	9	16	8	10
Middle	100	43	86	26	70	11	16
3rd	97	32	70	24	26	6	8
Bottom	20	5	15	5	9	6	3
Average moisture content, %	59	20	43	14	26	8	8

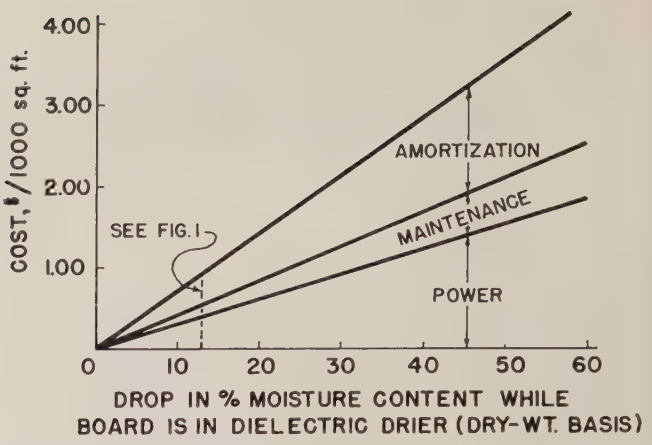

Fig. 2. Dielectric drying cost of 1/2-in., 20.5 lb./cu. ft. sheathing, produced at 40 f.p.m. (13-ft. wide sheet)

the moisture content dropped below 5%. Dielectric heating should not be expected to make boards moisture-free. Some manufacturers, however, use dielectric heating to obtain given moisture contents within close tolerances. This has been accomplished by the proper design of the electrical load circuit as furnished by the manufacturer.

The approximate cost of dielectric heating is shown in Fig. 2. The graph has been designed for determining costs for various amounts of water removed. Amortization cost assumes a 50,000-hr. machine life; maintenance cost assumes a 5000-hr. tube life, or $1.30 per M pounds of water removed; power cost assumes a rate of $0.01 per kw.-hr., that is, $3.60 per M pounds of water removed. If these figures change by reason of geographical location or improved electronic equipment design, the appropriate change can be made in the graph and the new total cost determined.

Table II. Cost of Electronically[a] Drying Wood Fiberboard from 20 to 7% Moisture Content at End of Coe Drier

Products	*3/8-in. Service board*	*1/2-in. Sheathing*	*25/32-in. Sheathing*	*1-in. Roof insulation*
Av. dry density, lb./cu. ft.	17	20.5	18.5	13.5
Assumed production rates				
ft./min.	45	40	25	20
sq. ft./hr.[h]	35,000	31,200	19,500	15,600
cu. ft./hr.	1,100	1,300	1,270	1,300
lb./hr.—dry	18,700	26,600	23,500	17,600
Assume 13% of water removed by dielectric heater, lb./hr.[b]	2,430	3,460	3,050	2,290
Approx. required investment at above water removal rate[c], dollars	380,000	560,000	480,000	400,000
Power cost,[d] $/hr.	8.75	12.50[g]	11.00	8.20
Maintenance cost,[e] $/hr.	3.15	4.50[g]	3.95	2.85
Capital cost,[f] $/hr.	7.60	11.20[g]	9.60	8.00
Total cost				
$/hr.	19.50	28.20	24.55	19.05
$/M sq. ft.	0.56	0.90[g]	1.26	1.22
$/M lb. water removed	8.00	8.20	8.10	8.30

[a] Typical hot-air drying cost of $3.20 per M sq. ft. from wet mat to moisture free conditions was used.
[b] At end of Coe drier.
[c] $100,000 drier removes 700 lb. water per hr.; $190,000, 1400 lb. per hr.; $370,000, 2800 lb. per hr.
[d] Based on $3.60 per M lb. water removed (power cost = $0.01 per kw.-hr.).
[e] Based on $1.30 per M lb. water removed (5000 hr. tube life).
[f] Assuming 50,000 hr. amortization.
[g] See Fig. 2.
[h] Assumed sheet of 13-ft. width.

The dashed line in Fig. 2 indicates the approximated cost of using the dielectric heater from points A to B, Fig. 1, in which 12% moisture content was removed. The cost was estimated to be about $0.90 per M sq. ft.

Another example will be cited, using Table I. When the dielectric heater was used for 5 min. after the board had been hot-air dried for 38 min. (see columns 3 and 4, Table I), the moisture content was reduced 29%. If this board were also the same dry density as the board in Fig. 2, the cost of removing 29% by dielectric heating can be found to be about $2.00 per M sq. ft. This would be added to the cost of the hot-air drying to give the total drying cost.

A cost sheet for dielectrically heating several types of wood fiberboard products is shown in Table II. The costs are figured on the basis that 13% moisture content is removed at the end of the drier to a final moisture content of 7%.

The cost per unit weight of water removed remained fairly constant, while the cost per M square feet varied somewhat. At present-day costs, an average figure of $8.25 per M pounds of water removed would appear satisfactory for original cost estimates.

CONCLUSIONS

Pilot plant tests have shown that dielectric heating can substantially increase the drying rate of wood fiberboard in existing drying equipment without the requirement of additional floor space.

By placing a dielectric heater at the exit end of a hot-air drier, the moisture from the wet center layer can be quickly dispersed through the board's thickness. Heat is generated in the wet center layer by dielectric heating at a time when the hot-air drier is least efficient. When a flat hot press is used, such as in a hardboard line, the press cycle may be shortened by removing partially dried sheets from the press and heating them dielectrically to a given moisture content.

Dielectric heating controls the final moisture content of the board to a fairly close tolerance, but does not produce moisture-free boards. Elimination of the normal humidification process is possible if heating to a moisture-free condition is not required to obtain desired moisture resistance.

Calculated dielectric heating costs, including present-day amortization, maintenance, and power costs for various types of wood fiberboard, produced at typical production speeds, ranged from $8.00 to $8.30 per M pounds of water removed. For example, a $^1/_2$-in. sheathing, dried from 20 to 7% moisture content, required 4 min. and was calculated to cost about $0.90 per M sq. ft

An increase in drying costs of about 30% by dielectric heating should increase drier capacity by about 20%.

Received March 15, 1960. Presented at the 45th Annual Meeting of the Technical Association of the Pulp and Paper Industry, held in New York, N. Y., Feb. 22–25, 1960.

A Statistically Based Sampling Procedure for Estimating Conformance to Basis Weight Specifications

JERROLD H. MOYER

Acceptance of a reel of paper or board implies that the product conforms to specifications throughout the entire reel. Of necessity, the decision to accept invariably depends on samples. Unfortunately, such decisions carry a risk of accepting a reel in which a proportion of the product is outside of specifications even though the sample is not. A method is suggested for estimating the magnitude of basis weight variability within a reel, and the respective contributions of machine and cross direction variation. The way in which this variation can affect the ability of a sample to truly represent the entire reel, and the design of an acceptance sampling plan based on knowledge of the within-reel variability is described. Statistically based acceptance sampling specifies the number of samples to be tested and an "acceptance limit" to which the sample average must conform. It is shown how this limit affects the risks of accepting reels in which an unsatisfactorily large amount of paper is outside of specifications or of rejecting reels which could satisfactorily meet the customer's specifications. It is made clear that acceptance limits are not likely to be as wide as specification limits.

Inspection of a manufactured product implies that a specification has been established with respect to that quality for which inspection is being made. When the purpose for the inspection is to determine whether the product is suitable for its next use, i.e., is in conformance with specifications presumably based on the next use requirements, we have an "acceptance inspection" situation. The sampling and testing procedure on which such acceptance inspection is based might then be thought of as acceptance sampling. In the present context, acceptance sampling refers specifically to a *statistically* based procedure of sampling, testing, and decision making with respect to accepting or rejecting the product. The discussion is centered around the reasons for applying acceptance sampling techniques to paper or board in reel (or roll) form at the end of the machine, with considerable detail as to the information needed before doing so.

The logic of acceptance sampling is not difficult to understand, although the underlying statistical techniques may be unfamiliar to the reader. It is the author's opinion that the growing emphasis in the industry on better adherence to quality specifications means that those concerned with establishing specifications, inspecting product, or administering the quality control function will benefit by an understanding of the principles involved in designing a statistically based acceptance sampling plan. When a reel of paper or board is sampled and tested for the purpose of decid-

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ing whether it conforms to specifications relating to that product, the possibility is often present that an erroneous decision may be made. A correctly designed sampling procedure can have the advantage of clearly evaluating the probability of making bad decisions, so that the risk to the producer of rejecting "good" reels is balanced against the risk to the consumer of being consigned "bad" reels, in an understandable manner which is fair to all concerned.

Acceptance sampling deals with the problem of product variability. It is necessary, therefore, to have some knowledge of the magnitude of inherent variability, i.e., the amount of variation to be expected in the product under "normal" conditions. Statistical quality control (SQC) is concerned also with variability, but there is a subtle difference between its objectives and those of acceptance sampling (*1*). SQC takes cognizance of inherent or normal variation in order to take corrective action *on the process* when there is indication that the normal variation is being exceeded. Sampling for quality control is not necessarily with reference to any particular unit or block of output, but is often related to some unit of time and is chronological. Acceptance sampling is concerned with predictable variability in order to make a decision *about the product.* Sampling for acceptance is always with reference to the unit (or lot in the case of piece parts) on which the decision to accept or reject is being made. Testing of paper or board samples taken from the end of the machine at reel turn-up can be for the dual purpose of quality control *and* product acceptance. Because the objectives are dissimilar, however, a control chart used in conjunction with end of the machine reel sample testing may not be the appropriate tool to use in making a decision as to whether the sampled reel conforms to specifications.

Acceptance sampling takes into consideration the following:

1. Specifications from the viewpoint of product variability.
2. Product acceptability in relation to product variability.
3. The possible error in a decision based on a sample because of product variability, and the influence of that error on the sampling plan.

Each of these will be dealt with in turn. In addition, the problem of interpretation of results when samples are restricted to reel turnups will be covered in considerable detail.

THE OBJECTIVES OF ACCEPTANCE SAMPLING

Product Variability and Specifications

Customer's specifications are, with some exceptions, set because the customer has found from experience that he is not able to process the product satisfactorily in his operation, or will not be able to use it as intended, if the quality in question is outside of the specification. Or it may be that the reason is purely economic, having very little to do with the suitability of the material. In any case, a specification is usually a numerical expression representing an upper and/or lower quality limit. The quality may be a count, an index, or a scale reading of a continuous variable such as Mullen, tear, basis weight, stiffness, etc. This discussion will be concerned with a method of determining whether the product conforms to the specification set for a continuous variable (*2*).

In order to have numerical examples, we will consider a hypothetical manufacturer of ice cream container stock. The problem will be the matter of determining whether the reels of board being shipped to the converter conform to basis weight specifications of that grade. Since the example is merely illustrative, the data to be used are "coded." Standard mill inspection procedure directs that a full web-width sample be taken at each reel turnup, and that the specimens for weighing be cut to a size approximately equal to the container blanks which are stamped from the web in the converter's operation, weighed, and converted to trade basic weight by a factor. A point to notice is that such samples are considerably smaller than the usual size used for basis weight determination, and might, therefore, be expected to be more sensitive to weight variation in the web.

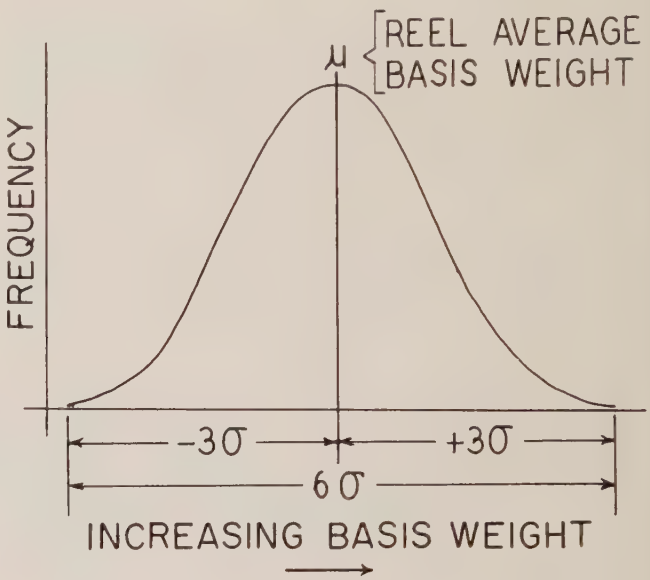

Fig. 1. Frequency of occurrence of basis weight values

Let us suppose that upper and lower specifications have been assigned in accordance with the requirements of the customer who has demonstrated to his own satisfaction that if basis weight is too low, the containers which he produces will be of poor quality. He has, therefore, set a lower specification limit, it being incumbent on the mill inspection to reject a reel testing below this limit. Conversely, because the customer is buying the product by weight and converting it "by the yard," it is uneconomical for him to accept board which is excessively high in basis weight. This leads to the establishing of an upper specification limit. In such a situation, this upper limit might represent a "price penalty" point rather than an outright rejection point. In any case, the mill is faced with a lower and upper limit within which the sampled unit—a reel of board—must be without suffering the penalty of rejection or of "down grading." The common practice would be for the mill to interpret these specifications as applying *to the sample* taken from each reel. It is possible that the customer would accept this viewpoint, but is this really what a specification should mean? The converter will be making ice cream containers from the entire reel, and he would certainly be unhappy if a large proportion of the reel were outside of the limits set, regardless of how well the reel end samples met his requirements.

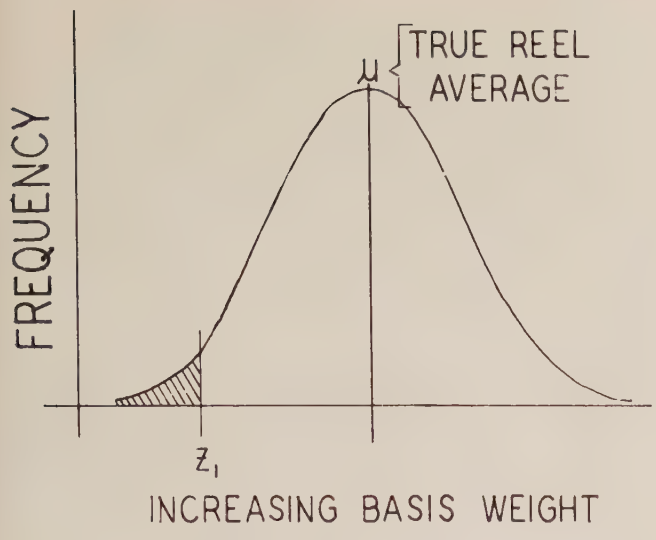

Fig. 2

Suppose that we were able to cut up an entire reel into specimens of the size which is used for determining basis weight, weighed all of the many thousand samples that would result, and made a frequency diagram of the various weights. We would very probably have a distribution which could be represented by the normal frequency curve. The true average basis weight of that reel will be known, because the entire reel has been tested. This true average will be designated as μ, and the magnitude of the variation within the reel can be represented by the standard deviation σ. This can be pictured as in Fig. 1.

It is, of course, impractical to determine the within-reel variation in this manner. A method will be described later for estimating σ. Assuming that we know the magnitude of product variability in terms of the standard deviation, the proportion of a reel having basis weight less than some value z_1 can be estimated for a particular reel average. If the value for z_1 is fixed and the true reel average changes, then the porportion of the reel less than z_1 in basis weight will change (of course, always assuming that σ remains constant). See Fig. 2. Similarly, it is possible to estimate the proportion *exceeding* some fixed value z_2. The effect of differing reel averages may be illustrated as in Fig. 3. Here the several frequency curves might be thought of as representing different reels, each with the same basis weight variation within the reel, but having different averages due to long cycle trends in process level occurring over several hours. With the μ's representing average basis weight for different reels and z_1 and z_2 lower and upper specification limits, respectively, then the proportion of any particular reel which exceeds either specification will depend on the process average at the time the reel is being made. It is reasonable to suppose that our hypothetical converter would have in mind that specification limits should apply to any part of the reel. As will be shown later, however, it can be quite possible for reels to be shipped to him in which a considerable part exceeds a limit, if these limits are interpreted by the mill as applying to the sample.

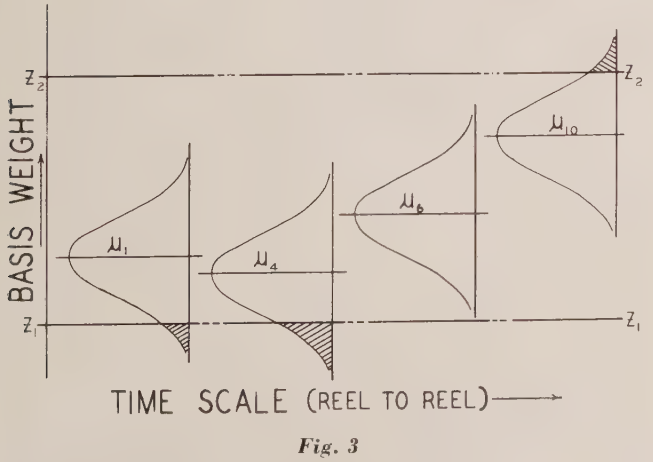

Fig. 3

Proper acceptance sampling defines two different sets of limits. One set represents the lower and upper limits with which the consumer is concerned, being applied to the reel as a whole. These are symbolized as the *LSL* (lower specification limit) and *USL* (upper specification limit). These are *not* applied to the sample. Rather, a second pair known as the lower and upper acceptance control limits (*LACL* and *UACL*) are designated for inspection purposes. These are the values which, if the *sample average* lies outside, will cause the sampled reel to be rejected.

Product Variability and Product Acceptability

It is obvious that a process capable of manufacturing board with very little variation from one point in the reel to another would permit operating with the average basis weight just inside the specification limit. There would be little likelihood of much of the reel being outside of limits, even through the reel average μ were near the *LSL* or *USL*. As product variability increases, a greater and greater percentage of the reel will be "off-spec" unless the increased variability is compensated for by holding the process average farther inside the limits. In many situations a compromise is necessary between the degree of control required to maintain a satisfactory average quality level and the proportion of the product "permitted" to be outside of specification. Generally speaking, the greater the variability, the more give and take there must be in the final compromise.

The foregoing introduces another concept with which acceptance sampling deals. This is the idea that a realistic specification may have to recognize and designate a proportion of the reel which could lie outside of the *LSL* and *USL* (not necessarily the same proportion with reference to both limits), and still be acceptable to the customer. This is not a self-defeating statement. It is quite possible that some small percentage of "defective" material is not objectionable, in that it would be "lost" in an otherwise properly performing consumer's operation. Even if trouble should ensue as a result of this small defective portion it could well be more economical, on balance, to accept this than to force the producer to further tighten up his operation. Such tightening up might require extensive and expensive alterations to the producer's process in order to reduce the within reel variability. Furthermore, a plan which might be designed to accept only those reels in which no board is outside the basis weight limits could also result in *rejecting* many reels which are entirely within the limits. Why this is so will become apparent in the later discussion. An inspection procedure, then, should accept most of the reels which are

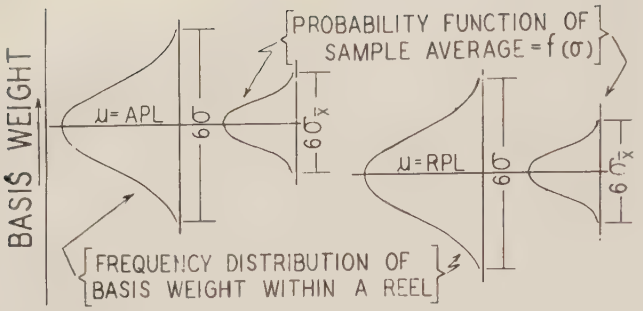

Fig. 4

"good" in the sense that they contain only a small quantity of defective board.

There is yet a third factor which a good set of specifications should consider. This is the proportion of defective, i.e., out of limits, material in the sampled unit which is definitely objectionable to the consumer and should cause the reel to be rejected. An acceptance sampling plan should have a low probability of accepting any reel in which enough of the product is outside of either the *LSL* or *USL* to be definitely unacceptable.

In acceptance sampling terminology, the "acceptable" percentage of off-spec board in the reel defines the acceptable process level, or *APL*, and a percentage great enough to be definitely objectionable defines the rejectable process level, or *RPL*. Process levels, i.e., reel averages, are represented by the μ's of Fig. 3. There is, therefore, a particular reel average for each specification limit which represents the *APL*, and another reel average (one for each limit) representing the *RPL*. It should now be admitted that—for a product characterized by quality variability—product acceptability must be considered in terms of more than what are commonly called the specification limits.

One other problem remains. How well can we guarantee that our inspection procedure (sampling plan) will accept reels which are at the *APL* and reject those at the *RPL*?

Product Variability and the Reliability of Samples

We must depend on a sample to indicate the quality of the reel. Whether the test of one sample or the average of several samples per reel is used, we tend to regard the result as being "typical" of the reel, that is, it estimates the true reel average. However, it must be admitted that the average of only a few—or even many—samples is very unlikely to be exactly the same as the true average basis weight of the reel, μ. It is reasonable that the more variability there is within the reel, the greater could be the "error" in the sample. How does our confidence in the sample results affect an acceptance sampling plan?

It has been stated that the sampling plan should accept *most* reels for which μ (true reel average) equals the *APL* (process level at which the reel contains a small but, by definition, acceptable proportion of off-spec board), and reject *most* reels whose μ equals the *RPL* (process level at which the reel contains an objectionably large off-spec proportion). Acceptance sampling defines the probability of rejecting reels at the *APL* as the producer's risk (α risk), and the probability of accepting reels at the *RPL* as the consumer's risk (β risk). It may seem strange that when we have already modified the idea of specification limits by admitting that it may not be possible, or at least not economical, to pass only reels having no product outside of the specification limit, we further admit that we will even pass some reels that are so bad as to be unacceptable to the consumer. Conversely, we will expect to reject some "good" reels. The answer, of course, lies in the possible error in the estimate of μ by the sample average $\bar{x}$.

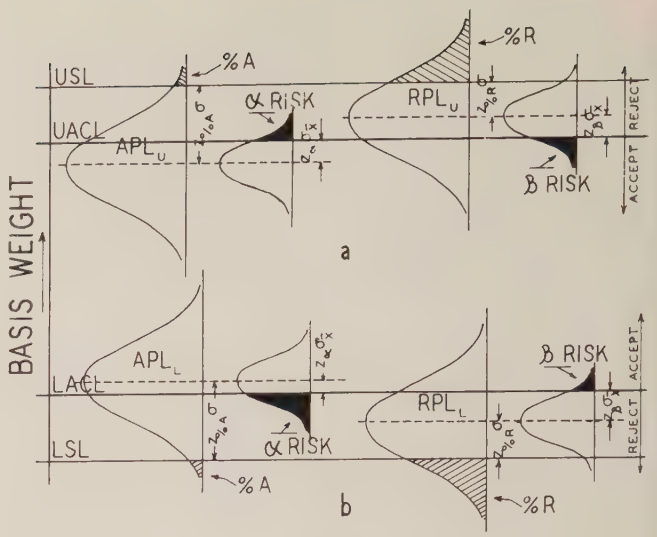

Fig. 5

The measure of this possible error, known as the standard error of the mean $\sigma_{\bar{x}}$, can be calculated. It depends on the within reel variability σ, the number of samples tested for the average $\bar{x}$, and location in the reel from which the samples are taken. The sample average can differ from the true reel average by as much as $3\sigma_{\bar{x}}$, that is, a sample average would be expected to lie in the range defined by $\mu \pm 3\sigma_{\bar{x}}$. Knowing the value of $\sigma_{\bar{x}}$, the probability of a sample average deviating from the reel average by more than a particular amount can be estimated. This can be pictured in Fig. 4, where the frequency distribution of basis weight within the reel is as in preceding figures, and the probability function of $\bar{x}$ is also represented as a normal curve.

One statement that may be made is that: (a) half of the time that the reel average is at the *APL* the sample average will be *less* than the *APL*, and (b) half of the time that the reel average is at the *RPL* the sample average will be *greater* than the *RPL*. Certainly we would not want to reject half of all those reels whose true average is at the acceptable process level, which is what would be expected to happen if the acceptance limit were made equal to the *APL*. Nor would we want to accept half of those at the rejectable process level, as would be the case if the *ACL* were set at the *RPL*. It is apparent that the reliability of a sample—in the sense of its being able to indicate the true reel average, and thus estimate the proportion of the reel outside of limits—is governed by variability within the reel.

Product Variability as It Affects Acceptance Limits

If a value lying between the *APL* and the *RPL* is selected as the acceptance control limit there would be less than a 50–50 chance of rejecting an acceptable reel

or of accepting a rejectable reel. The value selected, then, for this acceptance limit will determine the α risk and β risk. Since there can be only one *LACL* and one *UACL*, it is obvious that the α and β risks are not independent of each other. This is illustrated in Figs. 5a and 5b. The new symbols introduced are $\%A$, the proportion of the reel above the *USL* or below the *LSL* which is not objectionable, and $\%R$, the proportion which makes the reel definitely rejectable.

Figure 5 contains all of the factors and values required in the design of an acceptance sampling plan. To review, these are:

1. σ—A measure of the variation (standard deviation) in basis weight which has been determined to exist within a reel.

2. *LSL* and *USL*—The lower and upper specification limits, defining the minimum and maximum basis weight which should not be exceeded at any place in the reel in order to assure trouble-free operation for the consumer.

3. *APL*—That reel average basis weight which will result in a percentage of the reel ($\%A$) being outside of the specification limit which has been agreed will not cause serious difficulty to the consumer, or which would be uneconomical to try to reduce.

4. *RPL*—That reel average basis weight which will result in a percentage of the reel ($\%R$) being outside of the specification limit which is definitely unacceptable to the consumer.

5. α Risk—The risk that the producer is taking that a reel whose average is at the *APL* (and is, therefore, acceptable) will be rejected.

6. β Risk—The risk that the consumer is taking that a reel whose average is at the *RPL* (and is, therefore, unacceptable) will be accepted.

7. *LACL* and *UACL*—The lower and upper acceptance control limits defining the minimum and maximum basis weight within which the average of the reel sample must be in order for the reel to be accepted. A sample from a reel whose true average μ is at the *APL* has α probability of having an average $\bar{x}$ outside the *ACL*, causing the reel to be rejected. A sample from a reel with μ equal to the *RPL* has β probability of testing at or inside the *ACL*, causing the reel to be accepted.

8. $\sigma_{\bar{x}}$—Standard error of the mean from which can be calculated the probability of a sample average $\bar{x}$ deviating from the reel average μ by an amount equal to or greater than $\mu - \bar{x}$. $\sigma_{\bar{x}}$ is a function of σ and N.

9. N—The number of samples tested from a reel to determine $\bar{x}$. It should be noted that consideration is given to each of these in designing an acceptance sampling plan. In administering a plan, however, only the acceptance control limits, the sample size, and the sampling pattern need be stated. These are the only things with which the inspector is concerned.

The following equations relate the various factors involved in acceptance sampling:

$$APL = \begin{cases} LSL + |z_{\%A}|\sigma \\ USL - |z_{\%A}|\sigma \end{cases} \quad (1)$$

$$RPL = \begin{cases} LSL + |z_{\%R}|\sigma \\ USL - |z_{\%R}|\sigma \end{cases} \quad (2)$$

where $z_{\%A}$ and $z_{\%R}$ are found in tables of "areas under the normal curve from z to ∞" for the decimal per cent, A or R

$$LACL = \begin{cases} APL_L - |z_\alpha|\sigma_{\bar{x}} = RPL_L + |z_\beta|\sigma_{\bar{x}} \\ LSL + |z_{\%A}|\sigma - |z_\alpha|\sigma_{\bar{x}} = LSL + |z_{\%R}|\sigma + |z_\beta|\sigma_{\bar{x}} \end{cases} \quad (3)$$

$$UACL = \begin{cases} APL_U + |z_\alpha|\sigma_{\bar{x}} = RLP_U - |z_\beta|\sigma_{\bar{x}} \\ USL - |z_{\%A}|\sigma + |z_\alpha\sigma_{\bar{x}} = USL - \\ \qquad\qquad |z_{\%R}|\sigma - |z_\beta|\sigma_{\bar{x}} \end{cases} \quad (4)$$

where z_α and z_β are found in tables of "area under the normal curve from z to ∞" for the probability α or β

$$D = |z_{\%A}|\sigma - |z_\alpha|\sigma_{\bar{x}} = |z_{\%R}\sigma| + |z_\beta|\sigma_{\bar{x}} \quad (5)$$

where D is the difference between the specification limits and the acceptance control limits

$$D = \text{LACL} - \text{LSL} = \text{USL} - \text{UACL}$$

These formulas show that the nine factors involved in designing an acceptance sampling plan are not entirely independent of each other. In general, given any three, the remaining six are uniquely determined. Thus, the final set of specifications often represents compromises based on mutual agreement between the producer and consumer.

APPLICATION OF AN ACCEPTANCE SAMPLING PLAN

Let us return to a question rasied earlier. The hypothetical customer has furnished the producer with a pair of limits for basis weight of the ice cream container stock. Presumably, these were arrived at on the basis of the consumer's experience in making the containers, not on the basis of the producer's reel sample test results. If these limits are now applied to the reel samples, then *in the long run* those reels which test just at a limit will actually contain board half of which is outside that limit. Thus, the acceptance control limits should be moved inside of the specification limit enough to reasonably protect the consumer but not so far as to unduly penalize the producer.

Assume that the following have been determined (the method of doing so will be discussed later):

$$\sigma = 0.70$$
$$\sigma_{\bar{x}} = 0.38$$

Sample Pattern and Size

A full-width strip taken at each reel turnup, the strip divided into four equal width sections, and one specimen for basis weight determination cut at random from each section. The average from the preceding reel turnup is to be averaged with the result of the present sample to determine the disposition of the present reel. The specifications state the following:

$LSL = 45.0$
$USL = 49.0$
$\%R$ = 10% below the *LSL* and 20% above the *USL*
β risk = 0.05 on the *LSL* and 0.10 on the *USL*

This will uniquely determine the α risks for any given $\%A$. What should the *LACL* and *UACL* be set at?

	lower	*upper*
$z_{\%R}$	1.282	0.842
z_β	1.645	1.282

$$LACL = 45.0 + 1.282 \times 0.70 + 1.645 \times 0.38 = 46.5$$
$$UACL = 49.0 - 0.842 \times 0.70 - 1.282 \times 0.38 = 47.9$$

Assuming that the $\%A$ has been stated as being 0.5%

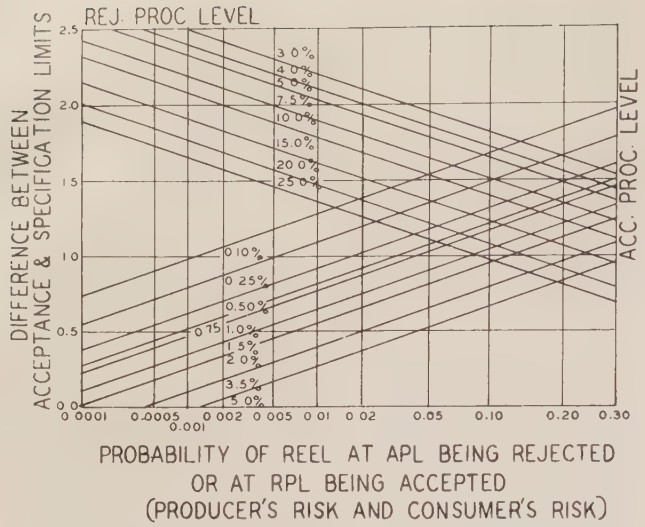

Fig. 6

for both lower and upper specification limits, the producer's risk under this plan is:

$$z_\alpha = \begin{cases} \dfrac{|z_{\%A}|\sigma + LSL - LACL}{\sigma_{\bar{x}}} \\ \dfrac{|z_{\%A}|\sigma - USL + UACL}{\sigma_{\bar{x}}} \end{cases}$$

$$z_\alpha = \begin{cases} \dfrac{2.576 \times 0.70 + 45.0 - 46.5}{0.38} = 0.798 \text{ (lower)} \\ \dfrac{2.576 \times 0.70 - 49.0 + 47.9}{0.38} = 1.851 \text{ (upper)} \end{cases}$$

$$\alpha = \begin{cases} 0.21 \text{ (lower)} \\ 0.03 \text{ (upper)} \end{cases}$$

The interpretation of this sampling plan is that 95 out of every 100 reels in which 10% of the board is below 45.0 basis weight will be rejected, if the rejection point is any reel sample testing below 46.5. Also, 90 out of every 100 reels containing 20% of the board above 49.0 basis weight will be "detected" and a price adjustment made, if the sample "rejection" point is set at above 47.9. With this plan, on the other hand, 21 out of every 100 reels containing only 0.5% below the LSL can be expected to be rejected, whereas 3 out of 100 having only 0.5% above the *USL* will be penalized (pricewise).

Once σ has been determined, it is possible to prepare a graph depicting the α and β risks for a number of *APL*'s and *RPL*'s associated with any acceptance control limits which might be chosen for given specification limits. Such a graph would be with reference to a particular sample size and sampling pattern, i.e., for a particular $\sigma_{\bar{x}}$. The several curves representing *APL*'s and *RPL*'s can be plotted by calculating only two points per curve using equation (5) above, if arithmetic probability paper is used. For example, given

$$\sigma = 0.70 \text{ and } \sigma_{\bar{x}} = 0.38,$$

D for an acceptable percentage of 1.0 at α risks of 0.001 and 0.500 may be calculated ($Z_{\%A} = 2.326$, $z_\alpha = 3.090$ and 0.0).

$$D_1 = 2.326 \times 0.70 - 3.090 \times 0.38 = 0.45$$
$$D_2 = 2.326 \times 0.70 - 0.0 \times 0.38 = 1.63$$

Similarly, for a rejectable percentage of 10.0 at β risks of 0.001 and 0.500 D is found to be ($z_{\%R} = 1.282$, $z_\beta = 3.090$ and 0.0),

$$D_1 = 1.282 \times 0.70 + 3.090 \times 0.38 = 2.07$$
$$D_2 = 1.282 \times 0.70 + 0.0 \times 0.38 = 0.90$$

Figure 6 is a graph prepared in this manner for several acceptable and rejectable per cents. It clearly illustrates the interdependence of the several factors involved in acceptance sampling, and is a useful device in arriving at a satisfactory "compromise" on the complete statement of a rational specification.

It must be realized that even though your present inspection procedures are not statistically based, the underlying principles discussed here are present. The chances are that you are not satisfactorily conforming to what your customer interprets as your specification. In other instances you may have been forced into a tight set of specification limits designed to overprotect the consumer, which are causing you to reject reels which would be entirely satisfactory.

A METHOD FOR ESTIMATING WITHIN-REEL VARIABILITY

It is obvious that the standard deviation of basis weight *within* the reel plays a key part in acceptance sampling. How can this σ be determined? One way would be to take samples at several randomly selected points throughout a reel, and estimate variance by the usual mean squares formula

$$\text{est. } \sigma^2 = \frac{\Sigma(x^2) - [(\Sigma x)^2/N]}{N - 1}$$

The consumer can do this as he makes his cartons, but it has two disadvantages for the producer's quality control department. One is the obvious cost in lost production to gather such data when the board is not being sheeted. The other is that such a procedure, restricted as it probably would be to only a few reels, could very possibly give a nonrepresentative estimate of the variability.

The other way to measure σ is to take samples at reel turnups, providing that a properly designed and analyzed experiment is used. If there is no reason for basis weight to be different near the end of the reel simply because it is the end of the reel, or machine direction variation is not periodically in phase with the time required to produce a reel, then such "systematic" sampling can be satisfactory (*3*). Several full web width reel end samples are required to obtain a representative estimate. The more, the better, but at least 100 should be used. These must be from consecutive reels as will become apparent in the following discussion.

Design of the Experiment to Estimate σ

The recommended technique for estimating within reel variation is a component of variance analysis (*4*). There are several reasons for this, which are unnecessary to go into here. Suffice it to say that the experiment design should be such as to separate the sources of basis weight variability into long cycle machine direction, short cycle machine direction, differences between sections (large areas) in the cross direction, random variability in cross direction within sections, and variation due to the testing instrument or its operator.

Long cycle machine-direction (MD) variability is

that which occurs over a period of several reels, or even days, and is a part of the variance in the experiment designed for estimating σ, but is not a part of the variation within a single reel. Short cycle MD variation is defined for our purpose as that which occurs within the span of time required to produce one reel, and is a component of σ. If an average difference exists between cross-direction (CD) areas or sections, the final acceptance plan can make use of this knowledge by specifying that an equal number of samples be tested from each section. This would eliminate the contribution to the standard error of the sample mean arising from the section differences. By designing the experiment for estimating σ so that these sections conform to the way in which *rolls* are cut from the log, it would be possible to determine whether the sampling plan would be more efficient, overall, if applied to individual rolls rather than to the reel as a whole. To estimate random cross-direction variation, an equal number of test specimens must be selected from within each section into which the web-width strip is partitioned. At least two must be selected, and it is recommended that a table of random numbers be used to locate the position from within the section that the specimen will be cut.

In addition to these components of product variability, there may be random differences from one test to another owing to lack of reproducibility by the test instrument and/or differences in the way in which the inspector performs the test or reads the results. These two types will be grouped together as the testing error component. It could be estimated by having the test repeated at least twice on each experimental specimen, doubling the testing required for the experiment. It is not necessary to estimate error this well, and it is suggested that a separate experiment be set up in which only 30 or 40 specimens are each weighed twice in random order. Each would be weighed once and resubmitted to the inspector(s) for retesting in a different order and without identification with the previous results. If the testing error is of any consequence, it should be taken account of since it will appear as part of the variation in routine inspection results. It thus constitutes a part of the standard error of the mean $\sigma_{\bar{x}}$, but is not really a part of the product variability and must be discounted in estimating σ.

The experiment to determine within reel variation must be designed to measure each of these components, which are symbolized as follows:

Total machine direction component—represented by end of reel samples over a long period of time:

σ^2_M of the M_h; $h = 1 \ldots t$ reels samples

Note: This is not determined directly, but is subdivided into long and short cycle MD variance.

Long cycle machine direction component—represented by subgroups of consecutive end of reel samples

σ^2_L of the L_i; $i = 1 \ldots p$ subgroups each consisting of two (or more) reel samples ($p = t/n$)

Short cycle machine direction component—represented by consecutive end of reel samples within subgroups

σ^2_S of the $S_{j(i)}$; $j = 1 \ldots n$ consecutive reel samples ($n = 2$)

Cross-direction section component—represented by sections (or rolls) obtained by partitioning the cross-machine web

σ^2_R of the R_k; $k = 1 \ldots q$ sections per reel sample

Cross-direction within sections component—represented by individual test specimens selected at random locations in cross direction within each section

σ^2_C of the $C_{l(ijk)}$; $l = 1 \ldots s$ randomly selected specimens

Testing error component—represented by repeated weighings on the same test specimens

σ^2_E of the $E_{m(ijkl)}$; $m = 1 \ldots r$ weighings per specimen

Component Analysis

To illustrate the method we will revert to the producer of ice cream cartons. Let us suppose that 208 consecutive reel turnup samples were taken, each divided into four sections and two test specimens of the size regularly used for inspection cut at random from each section. These were submitted to the regular inspectors for weighing. An estimate of the testing error was obtained by selecting a number of samples at random which were weighed twice by each of four inspectors. Thus,

$t = 208$	$q = 4$
$p = 104$	$s = 2$
$n = 2$	

$m = 2$ for each of 39 specimens weighed by four inspectors.

The components analysis resulted in Table I. To determine the expected within reel variance, only certain of these components are added

Short cycle MD,	σ^2_S	$= 0.1614$
Between sections,	σ^2_R	$= 0.0958$
Short-cycle sect.,	σ^2_{SR}	$= 0.0$
Random CD,	σ^2_C	$= 0.2379$
Total,	σ^2	$= 0.4951$
$\sigma = \sqrt{0.4951}$		$= 0.70$

Standard Error of Sample Mean

Having determined the components of within reel variance, it is possible to combine these in the proper way to estimate the possible error in a sample mean. The value for $\sigma_{\bar{x}}$ thus calculated will depend on the way in which samples are taken from the reel. The general formula is

$$\sigma_{\bar{x}} = \sqrt{\frac{\sigma^2_S}{n} + \left(\frac{Q-q}{q-1}\right)\frac{\sigma^2_R}{q} + \frac{\sigma^2_{SR}}{nq} + \frac{\sigma^2_C}{nqs} + \frac{\sigma^2_E}{nqsr}}$$

Each of the subscripts and divisors has the same meaning as previously. The values to assign to factors in the divisors are those relating to the routine inspection procedure as to the number n of full web-width samples tested per reel, the number of sections into which the sample is divided q, the number of specimens per section s, and the number of times each is weighed r. Q is the number of sections used in the experiment designed to estimate the components, so that if q for routine inspection is the same ($q = Q$) the effect of σ^2_R is removed from the standard error. On the other hand, if routine inspection specifies that the web be divided into fewer than Q sections then we consider that there are $q(<Q)$ randomly selected sections and σ^2_R contributes to $\sigma^2_{\bar{x}}$ in the proportion $(Q\text{-}1)/[q(Q\text{-}1)]$.

It might be argued that n must equal 1 in any practical sampling procedure, since machine reel samples are usually available only at turnups. Remember, however, that σ^2_S is represented by the samples within subgroups which consist of two consecutive turnup samples. In effect, the short cycle MD component is

Table I. Analysis of Variance and Components Analysis for Basis Weight of Ice Cream Container Board

Effect	*Degree of freedom*	*Sum of squares*	*Mean square*	*F Ratio*	*Expected mean square*	*Component*
Main Effects						
Long cycle MD, L_i	$p - 1 = 103$	490.01	4.7574	2.67[a]	$nqsr\sigma^2_L + qsr\sigma^2_S + r\sigma^2_C + \sigma^2_E$	$\frac{L_i - S_{j(i)}}{nqrs} = 0.1860$
Short cycle MD, $S_{j(i)}$	$p(n - 1) = 104$	185.25	1.7813	3.63[a]	$qsr\sigma^2_S - r\sigma^2_C + \sigma^2_E$	$\frac{S_{j(i)} - C_{l(ijk)}}{qsr} = 0.1614$
Between sections, R_k	$q - 1 = 3$	120.98	40.3267	8.22[a]	$npsr\sigma^2_R + nsr\sigma^2_{LR} + sr\sigma^2_{SR} + r\sigma^2_C + \sigma^2_E$	$\frac{R_k - C_{l(ijk)}}{npsr}$[b] $= 0.0958$
Interactions						
Long-cycle sect., LR_{ik}	$(p - 1)(q - 1) = 309$	150.77	0.4879	n.s.	$nsr\sigma^2_{LR} + sr\sigma^2_{SR} + r\sigma^2_C + \sigma^2_E$	$\frac{LR_{ik} - SR_{jk(i)}}{nsr} = 0$
Short-cycle sect., $SR_{jk(i)}$	$p(n - 1)(q - 1) = 312$	105.50	0.3381	n.s.	$sr\sigma^2_{SR} + r\sigma^2_C + \sigma^2_E$	$\frac{SR_{jk(i)} - C_{l(ijk)}}{sr} = 0$
Residuals						
Random CD, $C_{l(ijkt)}$	$npq(s - 1) = 832$	456.25	0.5484	1.94[c]	$r\sigma^2_C + \sigma^2_E$	$C_{l(ijk)} - C_{m(ijkl)} = 0.2379$
Test error, $E_{M(ijkt)}$	$npqs(r - 1)$	...	0.2525		σ^2_E (estd. independently)	0.2525

[a] Significant at 0.001 level. [b] LR_{ik} would be subtracted but σ^2_{LR} was not significant, so it was pooled, along with $SR_{jk(i)}$, with the random cross-direction mean square = 0.4904. [c] Significant at 0.01 level.

estimated from the average difference between pairs of sequential reel samples which, over the long run, is an unbiased measure of variability occurring within the period required to produce one reel. In this sense, a sample at the end of a reel is considered to also represent the quality at the start of the next reel. The same reasoning can be applied to routine inspection so that the result of the immediately preceding reel can be averaged with the result from the current reel to get a better estimate of the true reel average μ of the current reel.

There may be several feasible sample patterns for routine inspection. The objective should be to test as many specimens as feasible, with these taken from the reel in a way to give the most efficient testing results. "Efficient" here means to provide the smallest standard error $\sigma_{\bar{x}}$ consistent with the least testing effort. In general, any increase in the number of specimens tested will reduce $\sigma_{\bar{x}}$, but the improvement may not be worth extra testing. Table II lists values for the standard error of the mean estimated for different sampling patterns, using the variance components of the ice cream container example. It should be noted that the interaction component $\sigma^2_{SR} = 0$, so that it does not appear in the estimate of $\sigma_{\bar{x}}$.

The biggest improvement is obtained by dividing the width into four sections from each of which specimens for testing are selected at random. Nearly as big a gain results from averaging two successive reel samples. Doubling testing effort by more specimens per section or more weighings per specimen produces marginal benefits. Other feasible patterns may be worked out depending on the particular circumstances. The example cited for calculating an acceptance sampling plan, and the basis for Fig. 6, was the sampling pattern for which $\sigma_{\bar{x}} = 0.38$.

GENERALITY OF THE METHOD

Although this discussion has centered around basis weight of a grade of board, the principles are applicable to any quality characteristic of paper or board measured on a variables scale. A further restriction is that the quality being measured should vary at random in the machine direction within a reel, and the variation should at least approximate a normal frequency distribution. The fact that our problem concerns web material with partitionable sources of variation, and with limited access to sampling in the reel form, dictates the rather elaborate experiment to estimate σ and $\sigma_{\bar{x}}$. Many situations in other industries do not require such a design in order to apply the techniques of acceptance sampling, but we are not so fortunate.

SUMMARY

The purpose of sampling from a reel as it is "finished" should be to determine whether the entire reel—not just the sample— conforms to specifications. This requires a knowledge of the magnitude of variation to be expected within a reel for those qualities, such as basis weight, which are measured on a continuous scale. If this can be reasonably described by the normal frequency function, it is possible to calculate that reel average which will result in an undesirably large proportion of the reel being outside of either the lower or upper specification limit. This is the rejectable process level. Conversely, the average which will cause only an acceptably small proportion to be outside of specification defines the acceptable process level.

When a decision to accept or reject the reel depends on sample test results it is essential to have some idea of the precision of the sample estimate of the true reel average. The probability of rejecting a reel which is at the *APL* (the producer's or α risk), and the probability of accepting a reel which is at the *RPL* (the consumer's or β risk) depends on the sample precision. The precision is measured by the standard error of the mean which is a function of within reel variance, sample size, and sampling pattern.

Table II. Estimate of $\sigma_{\bar{x}}$ for Various Sampling Procedures

How selected	*Number per reel sample* — *Specimens*	*Tests*	*Averaged with previous reel* — *No (n = 1)*	*Yes (n = 2)*
At random from entire reel width	one ($q = 1, s = 1$)	one ($r = 1$)	0.86	0.65
One at random from within each of the four sections	four ($q = 4, s = 1$)	four ($r = 1$)	0.53	0.38
Same as preceding, but with each specimen weighed twice	four ($q = 4, s = 1$)	eight ($r = 2$)	0.50	0.36
Two at random from within each of the four sections	eight ($q = 4, s = 2$)	eight ($r = 1$)	0.47	0.33

Statistically based acceptance sampling by variables designates acceptance control limits for the sample average which balances each of these factors. Since they are not all independent of each other, the final balance is often a compromise among desirable objectives.

The best estimate of within reel variance is obtained by an experiment designed to partition the total into components representing machine direction, cross-direction, and testing error variances. These may be estimated from a large number of reel end samples, with the analysis performed so as to separate machine direction into long- and short- (within a reel) cycle components, and cross-direction into sectional (or roll) differences, and random within-section variance. Besides providing a better estimate of σ, the components analysis is essential in correctly determining $\sigma_{\bar{x}}$, whose value will depend on the sampling pattern employed for the routine inspection acceptance sampling plan.

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Received Mar. 15, 1960. Presented at the 45th Annual Meeting of the Technical Association of the Pulp and Paper Industry, held in New York, N. Y., Feb. 22–25, 1960.

Characterization of Alkali Solubles of Cellulose by X-Ray Diffraction Analysis

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Various samples of cellulose were fractionated into α-, β-, and γ-cellulose, and each fraction was subjected to x-ray diffraction analysis. Thus far, no definite explanation has been given to the diagrams of the alkali-soluble fractions of cellulose. In this study a new diffraction pattern of xylan is disclosed, and the known pattern of mannan was ascertained. By the aid of these new materials almost all the diffraction patterns of cellulose fractions could be explained. The preparations of α- and β-cellulose of rayon-grade pulps show the patterns resulting from hydrate cellulose, while the preparations of γ-cellulose show the mixed diagrams resulting from xylan and mannan. Although the scientific and practical significance of the α-cellulose method is a matter of opinion, nevertheless the method is useful for separating non-cellulose carbohydrates from cellulose.

THERE have been a series of papers published in recent years on the characterization of alkali soluble fractions of cellulose materials by means of x-ray diffraction analysis (*1, 3, 4, 5*). In these studies the cellulose samples were divided into α-, β-, and γ-cellulose, according to the methods that are used technically, and each fraction was subjected to the x-ray diffraction tests. The preparations of α-cellulose showed, in general, the diagrams resulting from Cellulose II or mercerized cellulose, whereas the interpretations of diffraction diagrams of the β- and the γ-cellulose are not without dispute, but arouse questions relative to the analytical methods for cellulose. This would be due to the lack of knowledge about the diffraction diagrams of the chemical constituents other than cellulose.

Thus far the only diagram which has been referred to for the purpose of diffraction analysis of the alkali-soluble fractions of cellulose is that of hydrate cellulose. However, the alkali soluble fractions of wood pulps contain, in general, considerable amount of innate wood polysaccharides other than cellulose.

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Little is known of the x-ray diffraction diagrams of these chemical constituents. Xylan or wood gum has been thought to be amorphous, since only the diffraction pattern consisting of a single diffuse halo is known. In the course of our studies on the hemicelluloses, however, it was found that the samples of xylan, in the form of film prepared under certain conditions, always manifested the distinct diffraction diagrams consisting of a number of Debye-Scherrer rings. When the film was rolled, it manifested the fiber diagrams with the x-ray beam parallel to the film surface. The diagrams show the sample to possess the uniplanar orientation. The analysis of the diffraction diagrams leads to the postulate that the cell may possibly belong to the hexagonal class, and the dimensions of the axes of the hexagonal unit cell are given. The details of analysis of crystalline structure of xylan will be reported in another place.

The diffraction was measured by the photographic technique as well as by a Geiger counter x-ray diffrac-

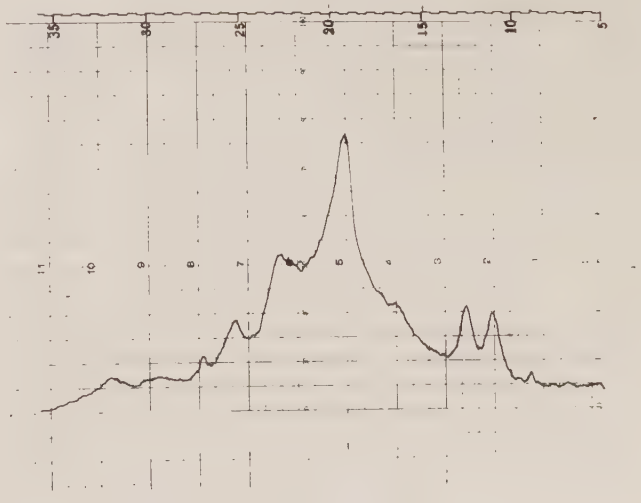

Fig. 1. Diffractometer trace of the x-ray diffraction pattern of xylan from beech

Table I. X-Ray Diffraction of Xylan Film from Beech

Cu K_α, λ = 1.54 A.

Maxima	Intensity	Angles of diffraction δ	sin $\delta/2$	Interplanar spacings d, A.
R_1	s	11°12′	0.0975	7.90
R_2	s	12°36′	0.1096	7.03
R_3	w	16°30′	0.1435	5.37
R_4	vs	19°24′	0.1680	4.58
R_5	m	22°36′	0.1960	3.93
R_6	w	25°18′	0.2186	3.52
R_7	w	27°00′	0.2335	3.30
R_8	vw	29°09′–29°51′	0.2520–0.2576	3.06–2.99
R_9	vw	32°00′	0.2756	2.80

vs = very strong; s = strong; m = medium; w = weak; vw = very weak.

tometer. Figure 1 shows the diffractometer trace of the beech xylan film, which is characterized by a number of selective reflections. The angles of diffraction maxima and interplanar spacings are given in Table I. It seems that the preparations obtained from water medium or the media containing water show the distinct diffraction patterns. If the water of the medium is completely replaced with organic solvents before drying the sample, as is done in many cases, the diffraction becomes diffuse, and the flat-plate diagram displays only a single broad halo.

The lattice of xylan is affected markedly by the mixed radicals such as arabofuranose and uronic acid groups. It has been found from a series of experiments that the interplanar spacings are enlarged to a certain extent in proportion to the content of uronic anhydride. The latter has had so profound an influence upon the crystallization that the samples containing a greater amount of uronic acids, such as those obtained from the softwoods like pine and larch, no longer show the crystalline pattern but a very diffuse diffraction resulting from an amorphous material. Figure 2 shows the diffractometer trace of xylan sample obtained from pine, which contains 73.3% of xylan and 21.2% of uronic anhydride. The molecular ratio is 4.6 xylose to 1 uronic acid. Xylan is hardly crystallizable when it has too many, up to a limit, uronic acid groupings. When purified, however, the diffraction becomes sharper.

A similar effect was already found by Yundt (*7*), who developed the method of preparing crystalline xylan by purification under somewhat drastic conditions. The method of Yundt was applied also to our sample of beech xylan, and a preparation with 98.1% xylan and D.P. 46 was obtained. This powder showed hexagonal platelets under an electron microscope and displayed almost the same diffraction pattern as that of the film sample. It was found later, from a private communication from Dr. Yundt, that the angle of diffraction maxima measured by him for the crystalline xylan from wheat straw coincided, on the whole, with those of our sample of beech xylan.

The lattice of xylan is very susceptible to water. When a sheet of xylan which was swollen in water is rolled, it no longer gives the Debye-Scherrer rings, but a diffuse halo with increasing intensity towards the equator. The crystallites are also sensitive to heat. When a sheet of xylan is heated at 100°C. in glycerol, the Debye-Scherrer rings diffuse into one or two broad halos. Thus the lattice of xylan has a greater sensitivity than that of cellulose.

Another important chemical constituent of cell walls

Table II. X-Ray Diffraction of Mannan A from Ivory Nut (a) and Pine (b)

Cu K_α, λ = 1.54 A.

Maxima	Intensity	Angles of diffraction δ (a)	(b)	sin $\delta/2$ (a)	(b)	Interplanar spacings d, A. (a)	(b)
R_1	vw	13°16′	...	0.1155	...	6.67	...
R_2	vs	15°57′	15°43′	0.1388	0.1367	5.56	5.64
R_3	m	18°13′	18°00′	0.1583	0.1564	4.87	4.93
R_4	s	20°03′	20°23′	0.1741	0.1769	4.43	4.36
R_5	m	23°47′	23°34′	0.2061	0.2042	3.74	3.78
R_6	m	25°21′	25°20′	0.2194	0.2193	3.51	3.52
R_7	vw	26°53′	...	0.2325	...	3.32	...
R_8	vw	29°40′	29°40′	0.2560	0.2560	3.01	3.01
R_9	vw	30°48′	...	0.2656	...	2.90	...
R_{10}	vw	33°14′	33°13′	0.2860	0.2858	2.70	2.70

is mannan, whose samples were obtained from pine on the one hand, and from ivory nut on the other hand. While the sample obtained from ivory nut is considered to be purely mannan, the mannan content of the sample prepared from pine is determined to be about 82% by quantitative paper chromatography. The residual sugar component of the latter is glucose. Thus the molecular ratio of mannose to glucose is about 4.5:1. It is becoming obvious during recent years that mannose in the coniferous woods is present as glucomannans.

Now, it is very interesting to see that both the samples of mannan, prepared respectively from ivory nut and pine, show very similar diffraction patterns, and the angles of diffraction measured by us agree on the whole with those reported by Hess and Lüdtke (*2*). Figure 3 is the diffractometer trace of the mannan from ivory nut, and Table II gives the angles of diffraction maxima of ivory nut mannan and pine mannan. Figure 4 shows a comparison of the diffraction diagrams of the mannan samples prepared from ivory nut and pine. The crystallinity of pine mannan is poorer than that of ivory nut mannan, probably owing to the complicated chemical composition.

Of the number of wood polysaccharides which are associated with cellulose in cell walls the two mentioned above are most abundant. It is reasonable to expect, therefore, that the diffraction diagrams of any fractions of cellulose can be related to the diffractions of these chemical constituents. Figures 5, 6, and 7 are the diffractometer traces of the α-, β-, and γ-cellulose of technical sulfite pulp of rayon grade from pine. According to paper chromatographic tests the glucose ingredient accounts for, respectively, about 98 and

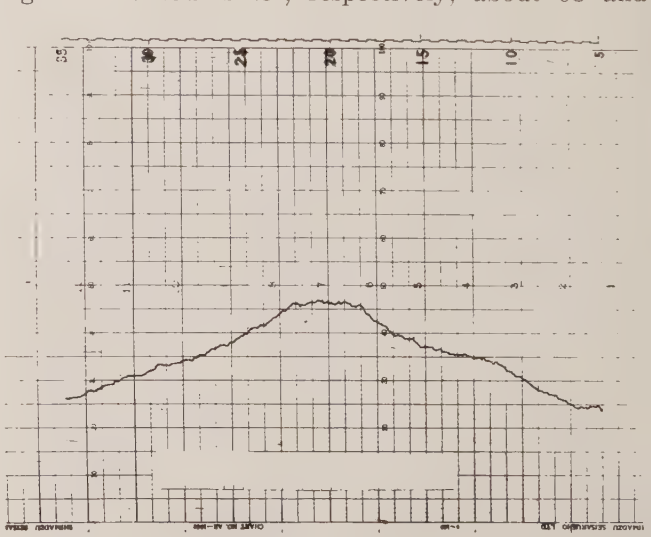

Fig. 2. Diffractometer trace of the x-ray diffraction pattern of xylan from pine

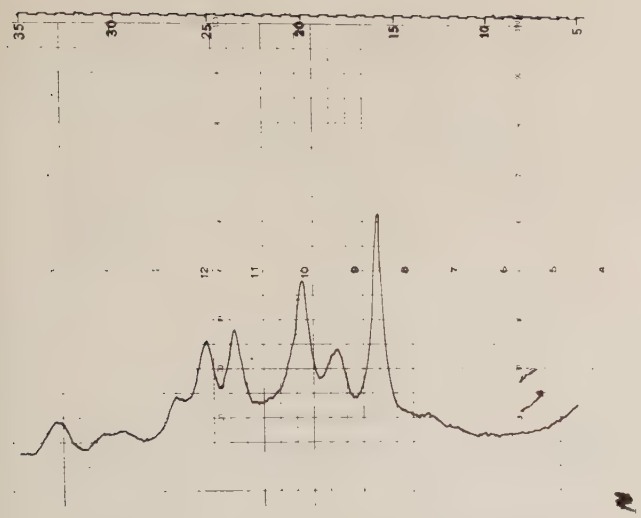

Fig. 3. Diffractometer trace of the x-ray diffraction pattern of mannan from ivory nut

96% of the weight of the α- and β-cellulose. The diffraction diagrams also show these fractions to be mostly cellulose II, as can be seen in Figs. 5 and 6. The comparison of both the traces, however, leads to the conclusion that the β-fraction may probably be crystallized to a greater extent than the α-fraction.

On the other hand, the γ-fraction of the same pulp shows a very different diffraction diagram, as can be seen in Fig. 7. *M* and *X* denote the postulated assignment of each prominent peak to mannan and xylan, respectively. No pertinent interpretation has so far been given to this type of diffraction patterns. However, if this diagram is compared closely with Figs. 1 and 3, it will be seen that the peaks in the xylan and mannan diagrams account for almost all the peaks that appear in the diagram of the γ-cellulose. The chromatographic test resulted in the approximate exposition of its composition as xylan 49%, mannan 46%, and cellulose 5%. It is to be noted, as mentioned before, that xylan of softwood seems to be less crystallizable than mannan.

It is evident that the chemical composition of every fraction may vary diversely according to the chemical constituents of the original material. For instance, the β-fraction of sulfate pulp from hardwood such as beech is composed mainly of xylan. The diffractometer trace shown in Fig. 8 is very reasonable, for every

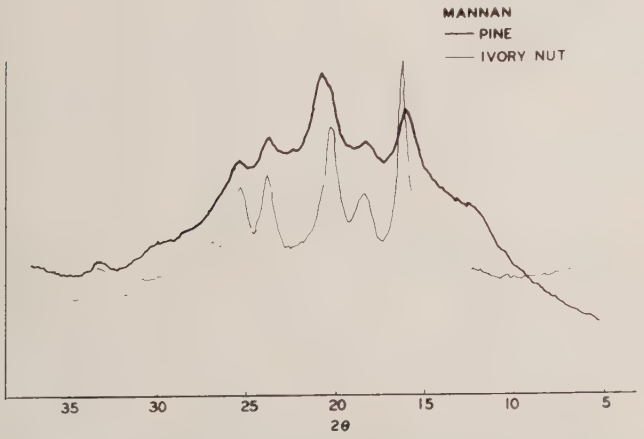

Fig. 4. Comparison of x-ray diffraction patterns of mannan samples prepared respectively from ivory nut and pine

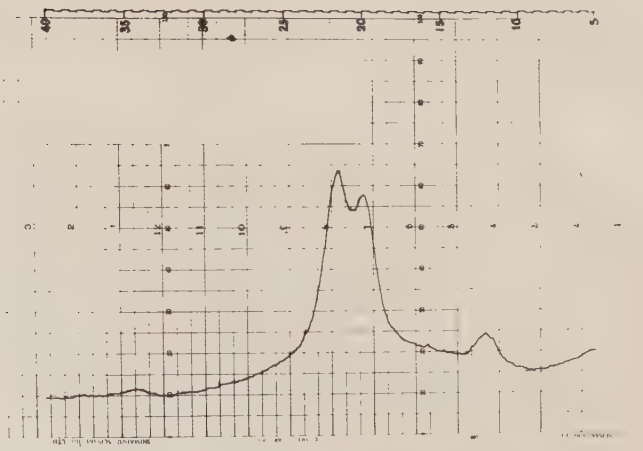

Fig. 5. Diffractometer trace of the x-ray diffraction pattern of α-cellulose of technical sulfite pulp of rayon grade from pine

prominent peak of the diagram represents that of xylan, as can be deduced by comparing it with Fig. 1.

The chemical composition of prehydrolysed-sulfate pulps for dissolving uses are very different from the

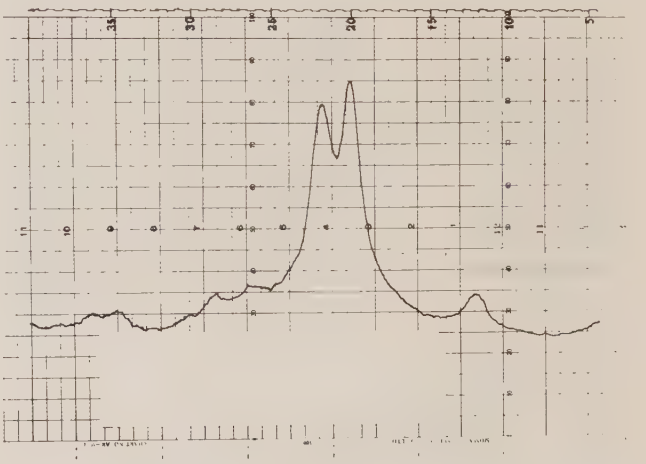

Fig. 6. Diffractometer trace of the x-ray diffraction pattern of β-cellulose of technical sulfite pulp of rayon grade from pine

ordinary sulfate pulps because of stronger elimination of hemicellulose during the whole pulping process. The constituent of the β-cellulose of prehydrolysed-sulfate pulp from pine is mainly cellulose similar to the case of

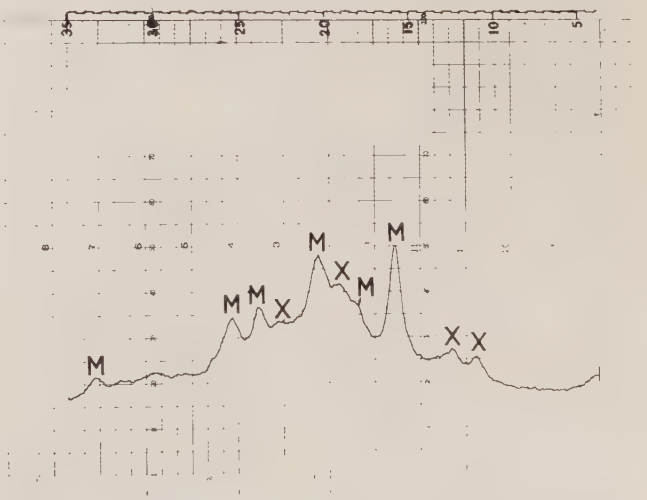

Fig. 7. Diffractometer trace of the x-ray diffraction pattern of γ-cellulose of technical sulfite pulp of rayon grade from pine

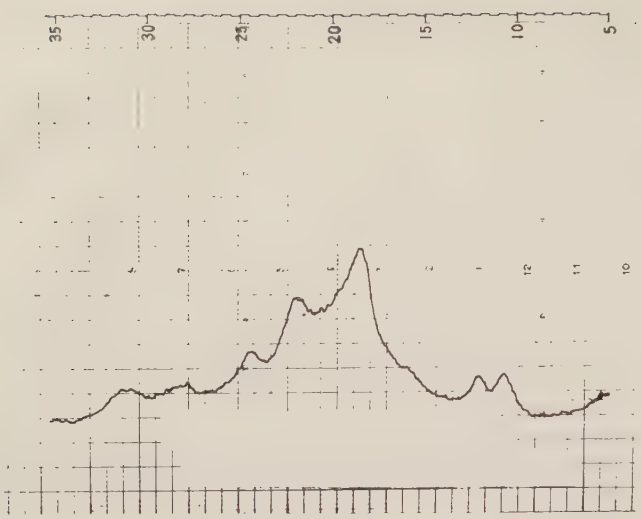

Fig. 8. Diffractometer trace of the x-ray diffraction pattern of β-cellulose of sulfate pulp from beech

dissolving sulfite pulps, as can be seen in Fig. 9, although the indication of xylan is seen in the diffractometer trace. The γ-cellulose of the same pulp gives a mixed diagram of mannan and xylan as was the case with dissolving sulfite pulp, although mannan appears to be predominant, as is shown in Fig. 10.

The diffraction diagrams of alkali solubles of cellulose which were published recently by several authors also seem to be interpretable when viewed in this light. Rånby (*5*) fractionated the spruce sulfite pulp of rayon grade (sample e) and bleached sulfate pulp for paper (sample f) into α-, β-, and γ-cellulose and subjected them to the x-ray diffraction test. The photometer curves of the α- and β-celluloses of both the samples turned out eventually to be those of cellulose II. As to the diffraction diagrams of the γ-celluloses, however, no persuasive explanation has been given.

Figures 11 and 12 are the reproductions of Rånby's photometer curves of γ-celluloses of sample e. The fraction γ-1 is precipitated spontaneously from the supernatant liquor over the β-cellulose after standing for one day at 4°C., and γ-2 is the fraction precipitated by replacing water with ethyl alcohol after removing the γ-1 fraction.

It is very interesting to see that almost all the peaks shown by γ-1 are exactly accounted for by the diffraction patterns of xylan. The values of sin δ/2 of the individual peaks of xylan reflection shown in Table I are denoted on the diagram in Fig. 11 together with the values of δ in parentheses. It can be seen that most of the peaks are those of xylan. The supposition of Rånby that γ-1 might be a pure phase would be valid on the whole, which turned out to be xylan, although the indication of coexisting mannan is distinct as denoted in Fig. 11. The photometer curve of sample f also can be interpreted in the same way.

The experiment leads to the conclusion that xylan deposits selectively when the supernatant liquor over the β-cellulose is kept standing at low temperature. When water is replaced with alcohol, another fraction, γ-2, precipitates. Its photometer curve, measured by Rånby, is given in Fig. 12. The new peaks which appear besides those of γ-1 might possibly be ascribed to the reflection peaks of mannan, as shown in Fig. 12. The values of sin δ/2 and δ in the figure are those

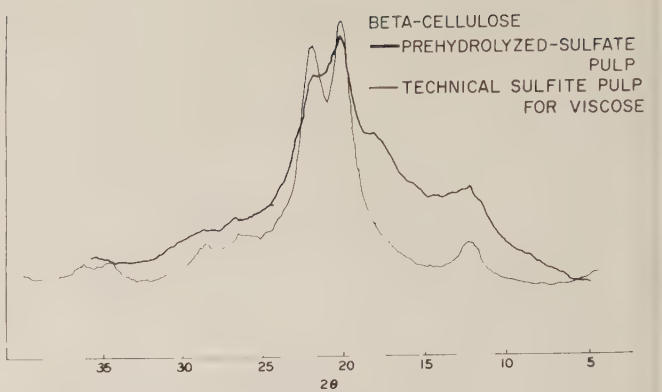

Fig. 9. Comparison of the x-ray diffraction patterns of β-cellulose of prehydrolyzed sulfate pulp from pine, and that of β-cellulose of sulfite pulp for viscose from pine

in Table II. It is evident that xylan and mannan are the chief chemical constituents of γ-2.

Recently Lindberg and Meier have tried to interpret the Rånby's diffraction diagram of γ-2 and have found that it might be a composed diagram resulting from a crystalline constituent having the same lattice as ivory nut mannan A and amorphous constituents. The interpretation would be more complete if the diffraction maxima resulting from crystalline xylan, which appear in the diagrams, were taken into account, as has been shown above. In other words Fig. 12 corresponds to our diagrams of Figs. 7 and 10, both representing the mixed diagrams of xylan and mannan.

Insofar as the diffraction diagrams of well-refined sulfite pulps and prehydrolysed-sulfate pulps from softwoods are concerned, the α- and β-celluloses are represented by that of hydrate cellulose, and the diffraction diagrams of γ-celluloses, in most cases, by the mixed diagrams of xylan and mannan.

Björkqvist, *et al.* (*1*) investigated the x-ray diffraction patterns of alkali soluble fractions of a number of cellulose materials. Surprisingly, however, they have not used 17.5% solution of sodium hydroxide, but 10 and 8% solution for fractionation, in spite of the fact that they aimed at the comment of the conventional methods for fractionation originated by Cross and Bevan. Furthermore, some of their samples are inadequate for the same purpose, for the fractionation into α-, β-, and γ-cellulose is originally standardized for characterization of pulps of the rayon and acetate grade. It is natural that the chemical compositions and diffrac-

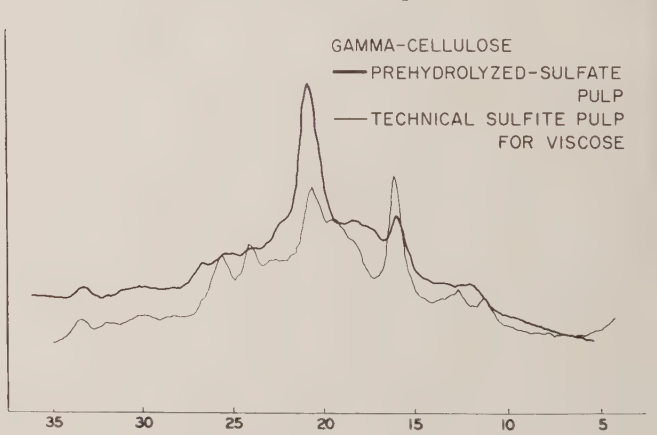

Fig. 10. Comparison of the x-ray diffraction pattern of γ-cellulose of prehydrolyzed-sulfate pulp from pine and that of γ-cellulose of sulfite pulp for viscose from pine

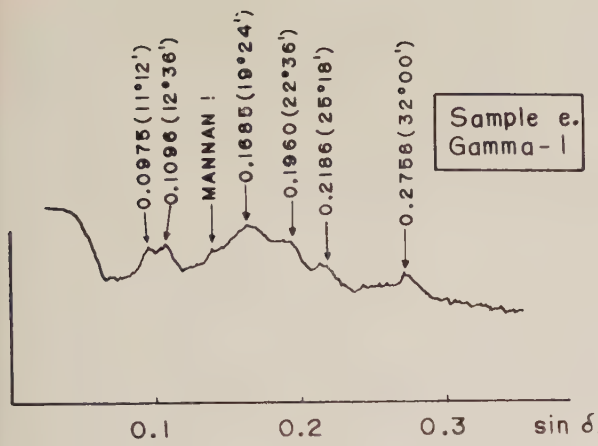

Fig. 11. The photometer trace of the x-ray diffraction pattern of γ-1 of sample e (spruce sulfite rayon-grade pulp), measured by Rånby, shows the correspondence of individual reflection maxima to those of xylan

The values of sin δ/2 and δ of the reflection maxima of xylan are denoted on the corresponding peaks of the trace.

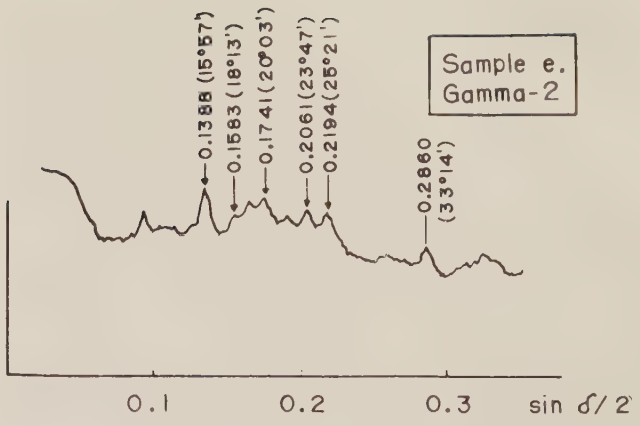

Fig. 12. The photometer trace of the x-ray diffraction pattern of γ-2 of sample e, measured by Rånby, shows the correspondence of the reflection maxima to those of ivory nut mannan

The values of sin δ/2 and δ of ivory nut mannan are denoted on the corresponding peaks of the trace. Peaks with no figures are mostly those of xylan reflection, as can be deduced from Fig. 11.

tion diagrams of alkali-soluble fractions are diverse, insofar as such a variety of samples are used. Therefore, it will not be pertinent to conclude from their study that the fractionation according to Cross and Bevan is of little use for the separation of definite chemical constituents. It would not be necessary to say much about their photometer curves, but, for instance, the diagram of the γ-fraction of 10%-NaOH extraction of the spruce sulfite pulp for rayon seems to reveal itself as a mixed diagram of mannan and xylan as was the case in ours as well as Rånby's samples.

Truly the x-ray diffraction method is not sensitive enough to detect a small amount of constituents, especially when they are less crystallizable polymer substances, so that it happens frequently that mixtures of polymers are represented by a diffraction of only a single constituent. However, it must be emphasized that the diffraction diagrams of the alkali-soluble fractions of celluloses, i.e., the β- and γ-celluloses are not so incomprehensible, but are accounted for by the diffractions of main chemical constituents comprising each fraction, which are sometimes highly crystalline and sometimes rather amorphous, according to the conditions. The crystalline state of the cell-wall constituents existing in the α-, β-, and γ-cellulose is thought to be connected not only with the inborn nature of wood, but also with the condition of cooking and bleaching processes. In this respect also x-ray diffraction analysis is thought to be useful for increasing knowledge of the changes occurring during the technical processes.

This work has been done to give a scientific background to our opinion concerning the alkali solubility tests recommended by the International Committee for Cellulose Analysis. The Committee was of the opinion that an internationallly adopted method for determination of alkali solubility was needed instead of the existing α-cellulose methods which, according to the records of the meetings of the Committee, today have only minor meaning from both the scientific and practical standpoint of view. One of the greatest reasons was that the conventional methods of fractionation of cellulose materials into α-, β-, and γ-cellulose had no scientific bearing on the fractionation into their chemical constituents. It should be emphasized that this was too hasty a conclusion, as can be seen in the materials involved in this paper.

In most of the cases, so far as the cellulose materials for chemical uses are concerned, the α-cellulose is, on the whole, the high polymeric cellulose in the sugar-chemical sense, the β-cellulose the lower polymeric cellulose, while the γ-cellulose is a mixture of non-cellulose carbohydrates such as xylan, glucomannan, uronic acids, and so forth. Although xylan and mannan can be found in a small amount in the low polymeric fractions of α-cellulose, they are almost exclusively concentrated in the γ-fraction. Thus the fractionation according to the chemical constituents is fairly satisfactorily achieved by the conventional α-cellulose method. The criticism of the α-cellulose methods is directed at the variety of ways involved in the procedure of rinsing the cake. Could this be standardized the α-cellulose method will further enhance the practical significance.

PROCEDURE AND SAMPLE PREPARATION

Separation of α-, β-, and γ-Cellulose

The separation of the α-cellulose was carried out, on the whole, according to TAPPI Standard T 203. However, the method had to be modified, as the purpose of the procedure in our case was not to determine the α-cellulose content but to obtain a sufficient quantity of β- and γ-cellulose. Our experiments were carried out on a scale about thirteen times greater than that of the TAPPI Standard, as follows.

Forty grams of pulp were treated with 1 l. of 17.5% solution of sodium hydroxide under merceration for 45 min. at 20°C. One liter of water was then added under vigorous stirring, and the mixture was filtered immediately by means of suction on a fine-glass filter. The filtrate was poured through the cellulose mat to catch any fine material. The filtrate was acidified with acetic acid up to pH 5 to precipitate β-cellulose, and the mixture was warmed to promote the coagulation of the precipitate, which was allowed to settle, separated by centrifuging, and washed several times with water. The water was then replaced with methanol, and the methanol with ether, to facilitate drying.

The supernatant liquor, over the β-precipitate, was transferred to a large beaker, and a large amount of methanol about three times the volume of the liquid already present, was added and the mixture allowed to stand for 12 hr. to allow the precipitate of γ-cellulose to settle. The precipitate was separated by centrifuging and washed repeatedly with 60% methanol to remove the inorganic impurities. The γ-cellulose was converted into film in the same manner as in the case of xylan preparation.

Beech Xylan

Beech holocellulose prepared by the method of Wise, *et al.* (*6*) was first extracted with 0.2% NaOH solution and 50 g. of the residue was treated carefully with 250 ml. of 8% NaOH solution for 3 hr. in a hydrogen atmosphere, to eliminate oxidative degradation. The extracted liquor was neutralized with glacial acetic acid. Dry methanol, equal to three times the volume of the liquor, was added to complete the precipitation of hemicelluloses. The crude xylan thus precipitated was separated by centrifuging, and treated with 400 ml. of 0.2% chlorine dioxide solution for 5 hr. at 50°C. The preparation was washed a further six times with 80% methanol, and the methanol was replaced by ether. The ether-wet sample was dissolved in hot water, cooled, and subjected to electrodialysis for 24 hr. The purified solution was concentrated by heating on a water bath, and when the liquid became suitably viscous, a portion of it was spread on the surface of a clean glass plate, and the water was further evaporated until a clear film was formed on the surface of the glass plate. The purity of xylan was estimated at 87–91% from the amount of the furfural produced. The uronic anhydride content was determined to be 3 to 5% by measurements of carbon dioxide evolution. The D.P. was estimated at about 80 from osmotic pressure measurements. It is clear, therefore, that the xylan was degraded considerably during the procedure.

The xylan samples as prepared above contained, in general, 1.0 to 1.5% of ash. Some of these inorganic impurities are thought to be the products of reactions taking place in the xylan separation procedure. Here, the most probable constituent would be sodium acetate. Also, it was found occasionally that the positions of diffraction maxima of the hydrate of sodium acetate were very similar to those of xylan, although the sharpness and intensity relation of diffraction patterns were remarkably different. Therefore, it seemed necessary to show that the diffraction of xylan preparations, as described here, is peculiar to xylan itself and has not been affected by the impurity.

Evidence was given by the experiment with xylan films which had been prepared in the absence of sodium; potassium hydroxide was used instead of sodium hydroxide for the extraction of xylan. In this case the possible ash constituent is potassium acetate, which shows utterly different diffraction pattern from that of sodium acetate. However, the diffraction pattern of the xylan film prepared by using potassium is identical with that of the sample made by using sodium.

While the diffraction pattern of sodium acetate changes completely when it is dehydrated by heating, the diffraction of the xylan preparation does not change even under dehydration. To test further the effect of sodium acetate upon the diffraction pattern of organic substance, some model experiments were carried out with the samples of soluble starch which had been mixed with sodium acetate in various amounts. The experiment showed that no perceptible indication of sodium acetate diffraction was observed, when its content was as small as 1.0 to 1.5%.

Pine Xylan

Fifty grams of holocellulose of pine wood meal (*Pinus densiflora*) prepared by the method of Wise, *et al.* (*6*) was treated with 24% NaOH solution, and the extracted hemicellulose was precipitated by adding methanol after neutralizing the solution with glacial acetic acid, as was done for the separation of beech xylan. The hemicellulose thus precipitated was washed six times with 80% methanol and dissolved in hot water to a concentration of about 1%. The 28% ammonium solution and copper hydroxide were added to make the content of NH_3 25% and that of $Cu(OH)_2$ 10 g.p.l. Carbon dioxide was introduced to the mixture to complete the dissolution of hemicellulose. The concentrated solution of sodium hydroxide was added to make the 0.1 *N* solution, and the mixture was kept standing for 3 hr. to settle the precipitate of copper-mannan complex compound, which was separated by centrifuging. While the precipitate was composed mainly of mannan compounds, xylan was found mainly in the supernatant liquid. The precipitate was used for separation of pine mannan, while the liquor was used for separation of pine xylan. The liquid containing xylan was neutralized with glacial acetic acid, and three volumes of methanol were added to precipitate the crude xylan, which was washed several times with 80% methanol. The preparation was dissolved again in cuprammonium solution, and sodium hydroxide solution was added as above to separate the mannan as a precipitate. Xylan was obtained from the supernatant liquid in the same manner as above. To enhance the purity of xylan the preparation was further subjected to a series of procedures, as described above. The last preparation thus obtained contained 73.3% xylan and 21.2% uronic acid. The ratio of xylose residue to uronic acid residue is 4.6:1. The uronic acid adheres to the xylan more persistently than in the case of beech xylan. The pine xylan also could be converted into film, as in the case of the beech xylan.

Pine Mannan

The precipitate of copper-mannan complex compound which had been obtained in the previous procedure was treated with 10% acetic acid solution to regenerate the mannan. The crude mannan thus obtained was washed thoroughly with 80% methanol and dissolved in cuprammonium solution and precipitated again by adding the concentrated solution of sodium hydroxide in exactly the same manner as before. The mannan was then regenerated by acidifying the solution with acetic acid, and the precipitate was washed thoroughly by 80% methanol, and was subjected again to a series of procedures, as mentioned above. The purity in mannan of the last preparation was determined to be 82.0% by chromatography, while uronic acids were not found, and most of the residual sugar components was glucose. The molecular ratio of mannose to glucose

is 4.5:1. The D.P. was estimated at about 70 by osmotic pressure measurements. It is obvious that mannan was considerably degraded during the procedure.

Ivory Nut Mannan

The sliced endosperm of ivory nut was crushed in a mortar, treated with 0.2% chlorine dioxide solution at 50°C., washed thoroughly with water, and dried. The powder was extracted with 5% solution of sodium hydroxide in a hydrogen atmosphere. The liquor was neutralized and slightly acidified to a pH of 5, three volumes of methanol were added to the mixture. The precipitate, mannan A, was washed several times with 80% methanol and dried. The yield was 68.5%. Paper chromatography revealed that mannan A was pure mannan. The residue of mannan A was treated further with 10% solution of sodium hydroxide in hydrogen atmosphere, and mannan B was precipitated in the same manner as mannan A. The yield was 23.7%. This Paper chromatography showed that mannan B was also pure mannan. The residue of mannan B, only 0.5% of the ivory nut, showed the diffraction pattern of hydrate cellulose. The chromatographic test of the hydrolysate gave mainly the glucose spot and slight indication of a mannose spot. Mannan A (Table II) and mannan B show very similar diffraction patterns.

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This paper had been written originally to be presented at the 130th Annual Meeting of ACS at Atlantic City, in 1956. The material involved in this paper is almost the same as that in the original, although it has been supplemented with new material later.

Received Mar. 8, 1960.

Isolation and Properties of a 4-*O*-Methylglucuronoxylan from the Inner Bark of White Birch (*Betula papyrifera*)

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The extractive-free inner bark of white birch (*Betula papyrifera* Marsh.) has been found to contain a pectic acid (4.5%), an acidic xylan (26.6%), and cellulose (28.4%), in addition to several other polysaccharides (5.3%). Partial hydrolysis of the xylan gave D-xylose, 4-*O*-methyl-D-glucuronic acid and 2-*O*-(4-*O*-methyl-α-D-glucopyranosyluronic acid)-D-xylopyranose. Hydrolysis of the fully methylated polysaccharide ($\bar{P}_n$ = 86) yielded a mixture of 2-*O*- and 3-*O*-methyl-D-xylose, 2,3-di-*O*-methyl-D-xylose, 2,3,4-tri-*O*-methyl-D-xylose and 2-*O*-(2,3,4-tri-*O*-methyl-α-D-glucopyranosyluronic acid)-3-*O*-methyl-D-xylopyranose in a mole ratio of 15:62:1:9. The number- and weight-average degrees of polymerization of the original hemicellulose were 234 and 464, respectively. On the basis of this evidence it is suggested that this 4-*O*-methylglucuronoxylan contains a linear framework of a minimum number of 230 (1 → 4)-linked β-D-xylopyranose residues with, on the average, every tenth residue possessing a single, terminal side chain of a (1 → 2)-linked 4-*O*-methyl-α-D-glucuronic acid residue. The 4-*O*-methylglucuronoxylans present in the wood and in the bark of white birch are thus almost identical.

In spite of the considerable progress that has been made during the last 10 years in the chemistry of wood hemicelluloses (*1–3*), few, if any, polysaccharides have so far been isolated in a pure state from bark and no complete structural investigation has hitherto been reported. Bark and wood are very different, both morphologically and chemically, as could also be expected in view of their different functions in the tree (*4–6*). The general carbohydrate composition of many barks has been investigated (*7–15*) and both pectic material (*16–19*) and cellulose (*20*) have been isolated. A mucilage, peculiar to the inner bark of slippery elm, has been studied in detail (*21, 22*). Most recently, several polysaccharides have been isolated from the inner bark of white spruce and tentatively characterized (*23*).

The present study is concerned with the isolation of the polysaccharides present in the inner bark (secondary phloem) of white birch (*Betula papyrifera*, Marsh.) and especially with the properties of a 4-*O*-methylglycuronoxylan therefrom. The secondary phloem of this species contains sieve tubes, parenchymatic cells, sclereids, and bast fibers (*6*). The cells of the outer bark (cortex) are unusually rich in suberin (*24–26*).

Logs from an autumn-felled tree of white birch were immersed for some time in aqueous ethanol after which the brown, secondary phloem was easily separated manually from the secondary xylem and cambium on the inside and the cortex on the outside. The weight of the inner bark amounted to 10.5% of the entire trunk. Extraction with organic solvents and subsequently with water removed 4.7 and 6.0% of material. The water extract yielded a polysaccharide mixture, corresponding to 1.5% of the extractive-free bark. Extraction with hot, aqueous ammonium oxalate gave 4.2% of pectic material. When a portion of the residual bark was treated with alkali, 10.5% of a mixture of polysaccharides was obtained, containing galacturonic acid, galactose, glucose, mannose, arabinose, and xylose. This mixture could not be further resolved by precipitation with either Fehling's solution (*27*), barium hydroxide (*28*), cetyltrimethylammonium bromide (*29*) or cetyltrimethylammonium hydroxide (*30*). The bark remaining after removal of the pectin

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was, therefore, treated with acid chlorite which removed 25.0% of material, mostly of noncarbohydrate nature. The remaining portion, when exhaustively extracted with aqueous potassium hydroxide, yielded 26.6% of an acidic xylan. Subsequent extraction with sodium hydroxide containing borate (*31*) gave 3.8% of a material which was probably a mixture of polysaccharides. The remaining portion, 28.4%, was not amenable to further fractionation and constituted a pure cellulose.

The carbohydrate composition of the original bark and of the various fractions is summarized in Table I. The sugar composition of the bark agrees closely with previously reported values (*15*). The material extracted with ammonium oxalate contained only galacturonic acid and arabinose residues and the remaining portion only glucose. Later investigations (*32*, *33*) have shown these two fractions to consist of pectic acid and a degraded cellulose, respectively. Paper electrophoresis suggested that the portions extracted with water and with alkaline borate were mixtures of several polysaccharides and this was also suggested by their sugar composition.

The material extracted with sodium hydroxide, $[\alpha]_D^{20} - 68°$, gave only xylose and uronic acids on hydrolysis in addition to traces of glucose. It appeared to be electrophoretically homogeneous. The material yielding the glucose could be easily removed by washing with water.

Partial hydrolysis of the hemicellulose gave a mixture of sugars which was resolved on a column of anion exchange resin into a neutral and an acidic portion. The former contained only D-xylose, which crystallized. The acid fraction was resolved on a charcoal-Celite column (*34*) by gradient elution (*35*) with aqueous ethanol (*36*) to yield a hexuronic acid, an aldobiouronic acid, and a mono-*O*-methyl hexuronic acid. The hexuronic acid was identified as D-galacturonic acid through its crystalline methyl α-D-galacturonoside (*37*, *38*). The ester glycoside of the mono-*O*-methyl hexuronic acid was reduced with lithium aluminum hydride (*39*, *40*) to yield 4-*O*-methyl-D-glucose, characterized through its crystalline phenylosazone derivative (*41*, *42*). The acid was accordingly 4-*O*-methyl-D-glucuronic acid.

The methoxyl content and equivalent weight of the aldobiouronic acid, $[\alpha_D^{20}] + 101°$, corresponded to that of a mono-*O*-methyl hexuronosyl pentose (*43*). Acetylation of its methyl ester methyl glycoside yielded crystalline methyl 2-*O*-[methyl(2,3-di-*O*-acetyl-4-*O*-methyl-α-D-glucopyranosyl)uronate]-3,4-di-*O*-acetyl-D-xylopyranoside (*44*, *45*), identified through its melting point, specific rotation, infrared spectrum, and x-ray powder diagram. The aldobiouronic acid was accordingly 2-*O*-(4-*O*-methyl-α-D-glucopyranosyluronic acid)-D-xylopyranose.

The galacturonic acid was probably derived from a contaminating pectin, a material known to be abundant in bark cells. The presence of the xylose and the other two uronic acids suggested strongly that the hemicellulose was a 4-*O*-methylglucuronoxylan. Its uronic anhydride and methoxyl contents indicated the presence of an average number of 10 xylose residues per acid group.

The hemicellulose was methylated and the fully

Table I. Carbohydrate Composition of Bark and Bark Fractions[a]

Component	*Galacturonic acid*	*Galactose*	*Glucose*	*Mannose*	*Arabinose*	*Xylose*
Original bark	4	2	51	Trace	5	38
Water extract	5	8	25	16	11	35
Pectic material	90	Trace	Nil	Nil	10	Nil
Glucuronoxylan	Trace	Nil	Trace	Nil	Nil	87[b]
Alkali-borate extract	26	13	16	Nil	45	Nil
Residue (cellulose)	Nil	Nil	100	Nil	Nil	Trace

[a] In per cent of total reducing sugar content of each fraction.
[b] In addition to 13% of 4-*O*-methylglucuronic acid.

substituted product was subjected to methanolysis. The mixture of glycosides obtained was resolved into a neutral and an acidic fraction on an anion exchange resin. The acid portion contained only one component, the ester glycoside of which was reduced with lithium aluminum hydride to give crystalline methyl 2-*O*-(2,3,4-tri-*O*-methyl-α-D-glucopyranosyl)-3-*O*-methyl-α,β-D-xylopyranoside, identical with respect to melting point, specific rotation, and infrared and x-ray diagrams to an authentic specimen (*46*).

The hydrolyzate of the neutral glycosides was resolved on a charcoal-Celite column by gradient elution with aqueous ethanol. Fractions containing mono-*O*-, di-*O*-, and tri-*O*-methylxyloses were obtained in a molar ratio of 15:62:1. The electrophoretic behavior and specific rotation of the mono-*O*-methyl fraction suggested the presence of approximately equal quantities of 2-*O*- and 3-*O*-methyl-D-xylose. The second, and preponderant, fraction consisted of 2,3-di-*O*-methyl-D-xylose, identified through the crystalline β-sugar (*47*, *48*), as well as through its crystalline aniline derivative (*49*). The third fraction, which crystallized, was 2,3,4-tri-*O*-methyl-D-xylose (*50*).

The preponderance of 2,3-di-*O*-methyl-D-xylose among the methylated sugars in conjunction with the high negative rotation of the hemicellulose showed that the xylose residues forming the backbone of the polysaccharide were linked together by (1 → 4)-β-glycosidic bonds. The partly methylated aldobiouronic acid, obtained as only acidic product on methanolysis of the methylated hemicellulose, was unsubstituted at C_3 in its xylose moiety. The free aldobiouronic acid itself, when fully acetylated, contained a substituent in this position. On paper electrophoresis of the di-*O*-methylxylose fraction, no 3,4-di-*O*-methyl-D-xylose could be detected. This evidence indicates that the acid groups were attached *directly* to the xylan framework. The nature of the aldobiouronic acid showed that these acid side chains consisted of (1 → 2)-linked 4-*O*-methyl-α-D-glucuronic acid residues.

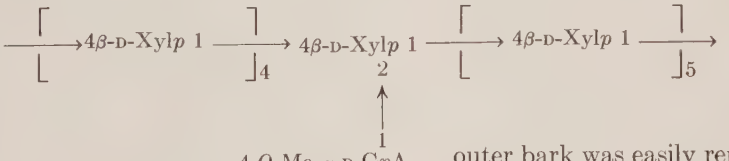
Since no acid side groups were removed during the methanolysis, the amount of mono-*O*-methylxyloses obtained, if structually significant, corresponded to the presence of one branching point in the macromolecule for every fifth xylose unit. Their number, however, greatly exceeded that of the tri-*O*-methylxylose, and the possibility that they might be artifacts had to be considered. The number-average molecular weight of the methylated polysaccharide was therefore determined by osmometry (*51*). The value obtained, 15,700, corresponded to a degree of polymerization (number of xylose residues in the main chain) of 86.

If it be assumed that the 2,3,4-tri-*O*-methyl-D-xylose isolated accounted for all nonreducing end groups, the D.P. derived on this basis was 87. Each macromolecule thus contained only one nonreducing end group and the polysaccharide was accordingly linear. The hydroxyl group at C_2 in both neutral (*52*) and acidic (*53*) xylans is considerably more reactive than that at C_3. The fact that equal amounts of the two mono-*O*-methylxyloses were obtained therefore strongly suggested that they were caused by demethylation rather than by incomplete methylation of the polysaccharide. Such a demethylation under conditions of acid hydrolysis of glycosidic bonds has been noticed on many occasions (*45*, *54*). The presence of incompletely methylated sugars in the hydrolyzate of an apparently fully substituted polysaccharide should never be considered as sufficient evidence for the presence of branching.

The osmotic pressure of the fully acetylated hemicellulose (*51*, *55*) suggested a number-average molecular weight of 55,800, corresponding to 234 xylose residues in the xylan backbone. Light-scattering measurements were carried out with dimethyl sulfoxide solutions of the polysaccharide. The weight-average molecular weight obtained was 70,000, corresponding to a D.P. of 464.

Oxidation with periodate indicated a consumption of 10.0 moles of oxidant per repeating unit of ten xylose and one 4-*O*-methylglucuronic acid residues, thus corroborating the above evidence.

A simplified structure can now be suggested for the 4-*O*-methylglucuronoxylan present in the inner bark of white birch. This polysaccharide contains a minimum number of 230 β-D-xylopyranose residues linked together by (1 → 4)-glycosidic bonds. The linear framework carries (1 → 2)-linked 4-*O*-methyl-α-D-glucuronic acid residues with an average number of 10 xylose units present per acid side-chain. The acid groups are probably distributed at random along the macromolecules (*56*). Whether *O*-acetyl groups are attached to the polysaccharide (*57*, *58*) in its native state is yet unknown. The hemicellulose is polymolecular and the ratio between the weight- and number-average degrees of polymerization (2.0) indicates a Flory distribution of molecular weights.



The present polysaccharide represents the first bark hemicellulose whose structure has been examined in detail, and comparison with other bark polysaccharides is therefore not possible. It is interesting to note that the constitution of the present bark hemicellulose is identical with that of the 4-*O*-methylglucuronoxylan forming more than one third of the wood of the same species (*59*). The number-average D.P. of the bark xylan (234) is somewhat higher than that of the wood hemicellulose (215). The bark polysaccharide had been subjected to the depolymerizing action of hot acid chlorite (*60*). The molecular weight of the native bark xylan as it existed in the tree was, therefore, probably considerably higher than that of the corresponding wood hemicellulose which had been isolated by direct alkaline extraction of the wood (*51*, *60*). This is rather surprising in view of the fact that the native cellulose present in white birch bark possesses a molecular weight which is somewhat lower than that of native birch wood cellulose (*61*).

It is evident from the present results that, when xylem is formed on the inside and phloem on the outside of the cambium during the period of secondary growth of the tree, the same 4-*O*-methylglucuronoxylan is formed in the same relative amounts on both sides. The identity of the two hemicelluloses is remarkable, considering the large morphological differences between the bark and the wood of a tree. The general carbohydrate composition of bark from gymnosperms (*6*, *21*) indicates that the present identity between the main wood and bark polysaccharides does not exist for this class of trees.

EXPERIMENTAL

All specific rotations are equilibrium values and were determined at 20°C. Melting points are corrected. Evaporations were carried out *in vacuo* at 40 to 50°C.

Paper Chromatography. Solvents (v/v) used for separating the sugars were (A) ethyl acetate-acetic acid-water (9:2:2), (B) *n*-butanol-pyridine-water (10:3:3), and (C) butanone-water (89:11). Separations were carried out by the descending technique on Whatman no. 1 filter paper. Electrophoretic separations of monosaccharides were carried out on Whatman no. 3MM filter paper at 750 v. for 4 hr. in 0.05 *M* borate buffer (*62*). The spray reagent was *o*-aminodiphenyl (*63*). For polysaccharides, glass-fiber paper and the same buffer solution were used at 1500 v. In this case, the spray reagent was α-naphthol (1 g.) in *n*-butanol (100 ml.), containing concentrated sulfuric acid (5 ml.). The *o*-aminodiphenyl method (*63*) in conjunction with paper chromatography was used for quantitative estimation of sugars.

Isolation of the Bark. A healthy specimen of white birch (approximately 30 years old) was cut in September, 1958, and the logs were immediately immersed and stored in 50% aq. ethanol for 2 to 3 days. The outer bark was easily removed by hand after which the brown inner bark was manually cut out with a knife in pieces, 5 by 8 cm. large. After soaking in methanol for several days, the bark was freed from adherent cambium and wood. The bark was dried in the air for a week, after which the brittle material was converted to sawdust in a Wiley mill, the 20- to 80-mesh fraction being collected. For isolation of further quantities of pectic material, a second tree was cut early in April, 1959, and processed in the same way. In this case complete separation of the inner and outer bark was more difficult and the former was lighter in color. The first tree contained 3.8% of outer and 10.4% of inner bark, based on the ovendry weight of the trunk.

The bark was analyzed by standard methods as described for the wood of the same species (*59*). The following values were obtained, based on the weight of the original bark: Klason lignin 28.6%, pentosan 26.7%, ash 5.2%, and uronic anhydride 6.9%. Successive extractions with ethanol-benzene (1:2, v/v) methanol and acetone removed 3.2, 0.8, and 0.7%, respectively, of the original bark. Similar successive treatments with cold and hot water and with 1% aq. sodium hydroxide eliminated 3.3, 2.7, and 7.4% of material.

Isolation of the Main Polysaccharides. Water-Solubles. Bark which had been exhaustively extracted with the above ethanol-benzene mixture, methanol, and acetone (11.0 kg.) was stirred with hot (70–80°C.) water (30 liters) for 3 days after which the remaining solids were recovered by filtration through paper and washed with hot water. The combined filtrate and washings were concentrated and the aqueous solution (2 liters) was added with stirring to ethanol (10 liters) to yield a precipitate which was washed successively on filter paper with 70% ethanol, 100% ethanol, and petroleum ether (b.p. 30–60°C.). Drying *in vacuo* over potassium hydroxide gave a slightly reddish powder (154 g.), corresponding to 1.5% of the extractive-free bark.

Pectic Material. The remaining material (10.3 kg.) was stirred with 0.5% (w/w) aqueous ammonium oxalate (60 liters) at 70 to 80°C. for 3 days. The solid portion was recovered by filtration and the combined filtrate and washings were concentrated to 4 liters. Calcium oxalate was removed by filtration and the clear solution was poured into ethanol (15 liters) to yield a precipitate which was recovered as described above as a white powder (440 g., 4.2%).

4-O-Methylglucuronoxylan. A portion of the residue (1.13 g.) was treated with acetic acid and sodium chlorite at 70 to 80°C. for 3 hr. (*64*). The remaining solids were collected by filtration, washed with distilled water, followed by ethanol, and dried. The weight of the residue was 828 g., corresponding to a removal of 25.0% of the extractive-free bark. This residual material was exhaustively extracted with 24% (w/w) aqueous potassium hydroxide (6 liters) at room temperature for 20 hr. The alkaline solution was removed by filtration through sintered glass and the solids were washed with water. The combined filtrate and washings were poured into a mixture of ethanol (25 liters) and glacial acetic acid (2.5 liters) containing solid ice (3 kg.). The precipitate formed was collected on the centrifuge and recovered in the usual way to yield a white powder (318 g., 26.6%).

Material Soluble in Alkaline Borate. The remaining material was exhaustively extracted with 17.5% aq. sodium hydroxide containing 4% boric acid (*31*). The alkaline solution, after filtration and precipitation in the usual way, gave a white powder (46 g., 3.8%), consisting of a mixture of polysaccharides.

Cellulose. The product recovered after the final extraction with alkaline borate was successively washed with dilute acetic acid, water, and ethanol. After drying *in vacuo*, a white powder was obtained (340 g., 28.4%).

Purification of the 4-O-Methylglucuronoxylan. The crude hemicellulose on hydrolysis yielded xylose, minor amounts of two uronic acids, and traces of glucose. The glucose-yielding component could be removed by extraction with water.

Anal.: (K-salt). Uronic anhydride = 9.91%, OCH_3 = 2.26%. $[\alpha]_D$ −68° (*c*, 1.0 in 10% NaOH).

Hydrolysis of the Hemicellulose and Preliminary Resolution of the Hydrolyzate. Hemicellulose (40 g.) was treated with 72% sulfuric acid (*65*) (30 ml.) at 30°C. for 4 hr. The solution was diluted to 1000 ml. and boiled under reflux for 7 hr. After neutralization with barium hydroxide, filtration through Celite and treatment with Amberlite IR-120 exchange resin, the solution was evaporated to yield a sirup (40 g.). An aqueous solution of this syrup was added to the top of a column (3.8 by 18 cm.) containing Dowex 1-X4 (acetate cycle) exchange resin. The resin was washed with water until no more sugar was removed (negative Molisch test). A portion of the eluate was evaporated to give crystalline D-xylose, m.p. and mixed m.p. 146 to 147°C., $[\alpha]_D$ + 18.2° (*c*, 4.0 in water). The dibenzylidene dimethyl acetal derivative (*66*) had m.p. and mixed m.p. 209 to 210°C. (*67*).

Separation of Sugar Acids. Elution of the exchange resin with 30% aq. acetic acid (4 liters) yielded a solution of acidic sugars which was evaporated to give a sirup (4.5 g.). Paper chromatography (solvent A) indicated the presence of a hexuronic acid, an aldobiouronic acid, and a mono-*O*-methylhexuronic acid. An aqueous solution of the sirup (4.0 g.) was added to the top of a column (3.5 by 55 cm.) containing a mixture of Darco G-60 charcoal and Celite (analytical grade) in a 1:1 mixture. Resolution (34) of the sugar mixture was achieved by gradient elution (*35*, *36*) with 3 liters each of water → 10% aq. ethanol and 10% ethanol → 20% ethanol. Fractions, 25 ml. each, were collected with an automatic fraction collector at an average rate of 50 ml. per hr. Three main fractions were obtained in the following order: galacturonic acid (0.60 g.), an *O*-methylglucuronic acid (0.50 g.), and an aldobiouronic acid (2.5 g.).

Identification of D-Galacturonic Acid. A portion of the hexuronic acid first eluted (100 mg.) was boiled under reflux with 0.7 *N* methanolic hydrogen chloride (75 ml.) for 7 hr. After neutralization with silver carbonate, filtration through Celite, and evaporation, the solution was treated with hydrogen sulfide, again filtered through Celite, and evaporated to a small volume. Needle-shaped crystals immediately formed. Recrystallization from ethanol gave the pure methyl α-D-galacturonoside, m.p. 149 to 150°C, $[\alpha]_D$ + 127° (*c*, 1.0 in water (*37*, *38*)).

Identification of 4-O-Methyl-D-glucuronic Acid. A portion of the mono-*O*-methylhexuronic acid (300 mg.) was boiled under reflux with 0.7 *N* methanolic hydrogen chloride in the presence of some Drierite for 7 hr. The methyl ester methyl glycoside was recovered in the usual way, dissolved in anhydrous tetrahydrofuran (50 ml.), and reduced with lithium aluminum hydride (*39*, *40*) (1 g.). Hydrolysis with *N* sulfuric acid gave 4-*O*-methyl-D-glucose (150 mg.), chromatographically indistinguishable from an authentic specimen (solvents A, B, and C). The 4-*O*-methyl-D-glucosazone (*41*, *42*) had m.p. and mixed m.p. 157 to 159°C.

Identification of 2-O-(4-O-Methyl-α-D-glucopyranosyluronic acid)-D-xylopyranose. The aldobiouronic acid (1.0 g.) was boiled under reflux with 0.7 *N* methanolic hydrogen chloride in the presence of Drierite for 7 hr. The methyl ester methyl glycoside (1.1 g.) was treated with pyridine (65 ml.) and acetic anhydride (25 ml.) to give the tetraacetate derivative (*44, 45*). Crystallization from ethyl ether yielded a mass of plates together with a small amount of needles. The two kinds of crystals were separated manually. The plates had m.p. and mixed m.p. 201 to 202°C., $[\alpha]_D$ + 101°C. (*c*, 1.0 in chloroform). The needles melted at 150 to 151°C. and again at 201 to 202°C.

Analysis

$C_{12}H_{20}O_{11}$		$C_{22}H_{32}O_{16}$	
Calcd.	*Found*	*Calcd.*	*Found*
C, % ...		49.2	49.2
H, % ...		6.02	6.16
OCH_3, % 9.1	9.4	17.3	17.3
Equiv. wt. 340	353		
Mol. wt. ...		536	536
$[\alpha]_D$*	+101°	...	...

* *c*, 1.0 in water.

The x-ray powder diagram and infrared spectrum of the tetraacetate were both identical with those of an authentic specimen (*45*).

From the above evidence it was concluded that the crystalline tetraacetate derivative was methyl 2-*O*-[methyl(2,3-di-*O*-acetyl-4-*O*-methyl-α-D-glucopyranosyl)uronate]-3,4-di-*O*-acetyl-D-xylopyranoside and that the aldobiouronic acid was 2-*O*-(4-*O*-methyl-α-D-glucopyranosylronicacid)-D-xylopyranose.

Methylation of the Hemicellulose. The hemicellulose (25 g.) was dissolved in 40% (w/w) aq. sodium hydroxide (400 ml.) in an atmosphere of nitrogen. Dimethyl sulfate (300 ml.) was added dropwise at 0°C. over a period of 20 hr. This treatment was repeated three times at room temperature. Solid sodium hydroxide (200 g.) was added, followed by dropwise addition of dimethyl sulfate (250 ml.). This process was repeated six times, water being added whenever necessary for efficient stirring. The reaction mixture was neutralized with sulfuric acid and diluted to three times its volume with water. On heating to boiling, the partly methylated hemicellulose separated as a solid cake which was recovered and washed briefly with hot water.

The dried product (21.0 g.) was dissolved in dimethyl formamide (200 ml.), freshly distilled over barium oxide, and silver oxide (50 g.) and methyl iodide (50 ml.) were added (*68*). The mixture was shaken at 30°C. for two days, after which silver oxide (50 g.) and methyl iodide (50 ml.) were again added. After shaking for two days, the grayish mixture of solids was exhaustively extracted with chloroform. The extract was washed once with 5% aq. potassium cyanide and then twice with water. After drying over anhydrous sodium sulfate, the chloroform solution was concentrated to 200 ml. and poured into petroleum ether (1.5 liter) to yield a precipitate which was recovered by filtration, washed with petroleum ether, and dried *in vacuo* over potassium hydroxide for three days. The white powder obtained (14.0 g.) still contained hydroxyl groups as indicated by its infrared diagram. The product was dissolved in methyl iodide (200 ml.) and shaken with silver oxide (20 g.) at room temperature for 24 hr. Silver oxide (20 g.) was added twice, after 24 and 48 hr., respectively. The product finally obtained on precipitation with petroleum ether (12.0 g.) contained only traces of hydroxyl groups.

The number-average degrees of polymerization of the methylated polysaccharide before and after the final Purdie methylation were 106 and 86, respectively, thus indicating the considerable degrading effect of the silver oxide used.

Anal.: Calcd. for the methyl ester of the fully methylated glucuronoxylan: OCH_3 = 39.2%. Found: OCH_3 = 39.1%.

Methanolysis of the Methylated Hemicellulose and Isolation of the Acidic Component. The methylated hemicellulose (7.0 g.) was boiled under reflux with 0.7 *N* methanolic hydrogen chloride (200 ml.). The recovered product (7.7 g.) was heated at 60°C. in aq. barium hydroxide for 2 hr. (*69*). After addition of solid carbon dioxide and filtration through Celite, the solution was treated with Amberlite IR-120 exchange resin to give a clear sirup (8.0 g.). The glycoside mixture was added to the top of a column of Dowex 1-X4 (acetate cycle) exchange resin. Neutral glycosides (6.5 g.) were removed by elution with water (3 liters). Elution with 30% aq. acetic acid (3 liters) gave an acidic syrup (1.4 g.).

Preparation and Identification of Methyl 2-O-(2,3,4-Tri-O-methyl-α-D-glucopyranosyl)-3-O-methyl-α,β-D-xylopyranoside. A portion of the acid syrup (800 mg.) was converted to its methyl ester methyl glycoside which was reduced with lithium aluminum hydride (2.0 g.) in dry ethyl ether (50 ml.) The disaccharide was recovered in the usual way to yield a pale yellow syrup which crystallized after seeding. After recrystallization from ethyl acetate the methyl 2-*O*-(2,3,4-tri-*O*-methyl-α-D-glucopyranosyl)-3-*O*-methyl-α,β-D-xylopyranoside (*46, 47*) had m.p. and mixed m.p. 166 to 167°, $[\alpha]_D$ + 91° (*c*, 2.0 in water). The x-ray and infrared spectra of the compound were identical with those of an authentic sample (*45*).

Anal.: Calcd. for $C_{16}H_{30}O_{10}$: C = 50.3%, H = 7.92%, OCH_3 = 40.6%. Found: C = 50.4%, H = 8.13%, OCH_3 = 40.1%.

Hydrolysis of the Methylated Neutral Glycosides and Resolution of the Sugar Mixture. The mixture of neutral glycosides (6.5 g.) was boiled under reflux with *N* sulfuric acid for 7 hr. to yield a mixture of reducing sugars (6.0 g.). Paper chromatography (solvent C) indicated the presence of a mono-*O*-methylxylose, a di-*O*-methylxylose and a tri-*O*-methylxylose. A portion of the mixture (3.0 g.) was added to the top of a column (3.5 by 55 cm.) containing Darco G-60 charcoal and Celite (1:1, w/w). Separation was achieved by gradient elution with 3 liters each of water → 10% aq. ethanol and 10% ethanol → 20% ethanol. Three main fractions were obtained, namely a mixture of two mono-*O*-methylxyloses (590 mg.), a di-*O*-methylxylose (2620 mg.), and a tri-*O*-methylxylose (45 mg.).

Preliminary Characterization of the Mono-O-methylxyloses. Paper electrophoresis indicated the presence in this fraction of approximately equal quantities of 2-*O*- and 3-*O*-methyl-D-xylose. The specific rotation,

Table II. Osmometry Data for Two Methylated Hemicelluloses

Before Purdie methylation			After Purdie methylation		
w[a]	h[b]	h/w	w	h	w/h
2.686	3.586	1.335	3.049	5.245	1.720
2.013	2.874	1.427	2.453	4.300	1.752
1.346	1.820	1.352	1.889	3.257	1.724
0.693	0.940	1.355	1.355	2.290	1.690
0.670	0.879	1.312	0.948	1.588	1.675
0	...	1.33	0	...	1.64

[a] Concentration in g./kg. solution.
[b] Osmotic height in cm. solution.

$[\alpha]_D$ + 27.5° (*c*, 2.4 in water) was also in agreement with such a composition.

Anal.: Calcd. for $C_6H_{12}O_5$: OCH_3 = 18.9%. Found: OCH_3 = 20.2%.

Identification of 2,3-Di-O-methyl-D-xylose. This fraction crystallized completely when seeded with an authentic crystal of 2,3-di-*O*-methyl-D-xylose. Recrystallization from ethyl acetate gave a product with m.p. 100 to 101°C. (*47, 48*), $[\alpha]_D$ + 14° → + 25° (equilibrium) (*c*, 2.0 in water). The derived 2,3-di-*O*-methyl-*N*-phenyl-D-xylopyranosylamine had m.p. and mixed m.p. 123 to 124°C. (*49*).

Anal.: Calcd. for $C_7H_{14}O_5$: OCH_3 = 34.8%. Found: OCH_3 = 34.8%.

Identification of 2,3,4-Tri-O-methyl-D-xylose. This fraction, on recrystallization from ethyl ether, had m.p. and mixed m.p. 90 to 91°, $[\alpha]_D$ + 18° (*c*, 1.0 in water) (*70*).

Periodate Oxidation of the Hemicellulose. Portions of the hemicellulose (K-salt, 100–150 mg.) were oxidized in the dark with 0.05 *M* sodium metaperiodate (50.0 ml.) at room temperature. The consumption of periodate was determined after various lengths of time by the excess arsenite method. The following moles of periodate were consumed (time in hr.) per repeating unit of the polysaccharide (mol. wt. 1548): 9.55 (18), 10.50 (43), 11.40 (96), 11.97 (140), 12.17 (163), 12.26 (186), and 12.50 (210). Extrapolation to zero time gave a value of 10.0 ± 0.5 moles.

Preparation of Hemicellulose Acetate. Hemicellulose (2.0 g.) was partly dispersed in dry formamide (40 ml.), and dry pyridine (80 ml.) and acetic anhydride (20 ml.) were added (*55*). The reaction was allowed to proceed at room temperature with continuous shaking and occasional cooling for 2 hr. Acetic anhydride (40 ml.) was again added and the reaction mixture was left for 2 days at +4°C. The gel formed was poured with vigorous stirring into ice water containing 2% hydrochloric acid (3 liters). The precipitate formed was washed on the filter with ice water until neutral and then with ethanol, followed by petroleum ether. Drying *in vacuo* yielded a grayish powder (2.5 g.), soluble in chloroform-ethanol (9:1, v/v).

Osmotic Pressure Measurements. The number-average molecular weights of the acetylated hemicellulose and of two methylated products were determined by osmotic pressure measurements in the above chloroform-ethanol mixture. Five osmometers of the improved Zimm-Myerson type (*71, 72*) were used, provided with membranes from cellophane which had never been allowed to dry. The static method of measuring the osmotic height was used, and the temperature was 30°C. Reduced osmotic pressures were plotted against concentration and linear extrapolation was carried out to zero concentration, thus yielding $(h/w)_{w=0}$, where h was the osmotic height in cm. solution and w the concentration in g./kg. solution. The number-average molecular weight, $\bar{M}_n$ was calculated from the relationship $\bar{M}_n = 25{,}700/(h/w)_{w=0}$ and the corresponding degree of polymerization (number of xylose residues in the main chain, $\bar{P}_n$) from the equation $\bar{P}_n = \bar{M}_n n/M_r$ where n was the number of xylose residues per acid side chain and M_r was the molecular weight of the repeating unit of the acetylated or methylated hemicellulose. The experimental results are given in Tables II and III.

Table III. Osmometry Data for Acetylated Hemicellulose

w	h	h/w
2.969	1.549	0.521
2.457	1.179	0.480
1.869	0.986	0.527
1.360	0.649	0.477
0.827	0.397	0.480
0	...	0.46

Light-Scattering Measurements. Light-scattering measurements were carried out with a Phoenix-Brice photometer, modified as described by Huque, Jaworzyn, and Goring (*73*), and calibrated with Ludox (*74*). Further experimental details have been reported elsewhere (*75*). Hemicellulose (acid form) was dissolved in dimethyl sulfoxide containing 2% (v/v) of water and the opalescent solution was clarified by ultracentrifugation at 140,000 *g* followed by centrifugation at 35,000 *g* in light-scattering cells specially designed for elimination of undissolved material (*76*). The wavelength of the light used was 5460 A. Corrections were not applied for dissymmetries which were very small. The following values were obtained for $C/I_{90°}$ at the respective concentrations (mg./ml.): 2.442 (1.27), 2.6262 (4.36), 2.519 (5.97), and 2.933 (8.30). Extrapolation to zero concentration gave a value of 2.35 for $(C/I_{90°})_{C=0}$. The refractive index increment used was 0.0641 ml. per g. as determined at a wavelength of 4358 A. The molecular weight, $\bar{M}_w$ was calculated from the relationship $1/\bar{M}_w = H(C/\tau)_{C=0}$, where the symbols have their usual significance. The value obtained was 70,000, corresponding to a $\bar{P}_w$ value of 464.

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Received April 22, 1960. Paper presented at the Symposium on Wood Hemicelluloses before the Division of Cellulose Chemistry at the 136th Meeting of the American Chemical Society in Atlantic City, N. J., September, 1959.

The authors wish to express their gratitude to D. A. I. Goring and T. J. Painter for valuable help and advice. Financial support from the American Viscose Corporation, Marcus Hook, Pa., and the National Research Council of Canada is gratefully acknowledged.

The Slime Board Method of Paper Mill Toxicant Evaluation

C. R. LECKEY

A device which can be used in the laboratory and on the paper machines for the evaluations of toxicants is described. The laboratory model is a system in which an artificial white water is circulated over the slime boards. The artificial medium described is specific for the study of a particular type machine furnish but modifications are mentioned. The machine model is attached directly to the machine and uses machine white water. The measure of microbiological toxicity is determined by making plate counts of the accretion. Both laboratory and machine data are given for three toxicants. There appears to be a good correlation between the two sets of data. However, further work is indicated because of insufficient data.

The major project in our microbiological program has been concerned with the development of a laboratory method for evaluating slime control toxicants. This is a complex problem and a considerable amount of preliminary work has been done to establish satisfactory testing conditions, apparatus, and procedures. The slime board method referred to in this paper involves the bacterial count per gram of slime, but not the total weight of slime.

A considerable volume of weight data have been collected, simultaneously with the count data, and it has became evident that the weight quantity is not reproducible.

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THE SLIME BOARD APPARATUS

Figure 1 is a schematic drawing of the slime board apparatus. The actual dimensions of the box and reservoir depend upon the specific applications. The dimensions of the box used in our laboratory are 10 in. long, 6 in. wide, and 7 in. high. The weir on this box is 6 in. high and accommodates two oak boards 7 x 2 x $^1/_2$ in. The reservoir is a 5-liter, open-mouth bottle which gives the system a total volume of 8 liters. The slime board aparatus that we use on the

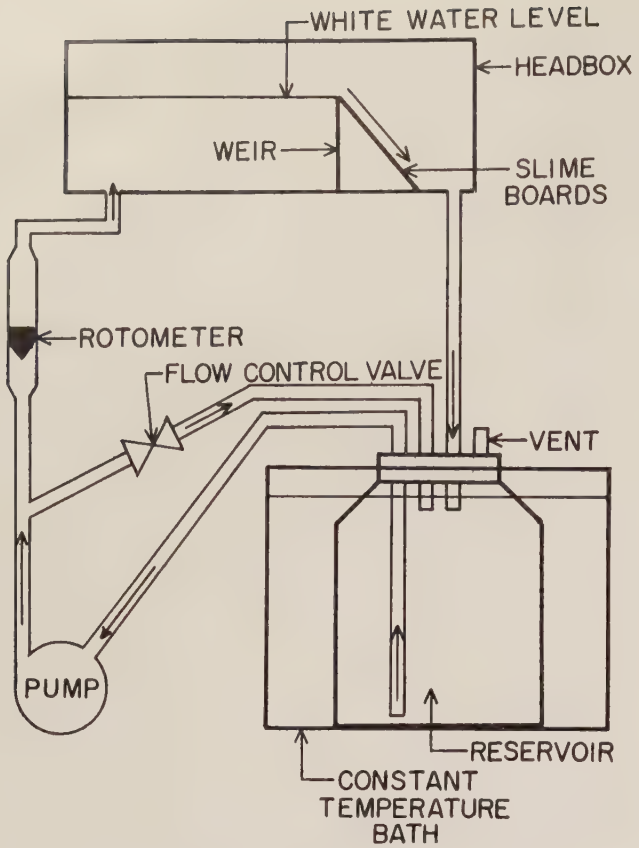

Fig. 1. Laboratory slime board apparatus

paper machines is a simplified modification of the laboratory setup. The box itself is the only portion of the apparatus that is used and it is fed by gravity, generally from the seal box. The external dimensions of the machine model are essentially the same as the lab box, but the weir is placed nearer the inlet to facilitate the use of larger boards.

EXPERIMENTAL

Preparation of the Articles for White Water

The composition of the artificial white water used in the laboratory apparatus is as follows:

Groundwood (sterilized), g.	8
KH_2PO_4 (buffer), g.	24
Starch (soluble), g.	8
KCS clay, g.	8
Distilled water, l.	8
Final pH	4.5

The groundwood was procured in quantities large enough to last several weeks; thus minimizing the variation from this source. Each batch of groundwood was taken from the mill system and squeezed to partial dryness. Then the semidried groundwood was sterilized by imersion in 100% methanol for 1 hr. The methanol treatment was repeated and the groundwood was allowed to dry overnight in a vacuum oven. Groundwood was selected as the pulp constituent of the artificial white water because it is generally recognized as being a superior microbiological substrate.

The potassium acid phosphate was used to buffer the system at a pH 4.5. On several occasions the pH was measured with a Beckman pH meter at the beginning and end of the test period, and no change in pH was ever detected. Also, phosphate is generally

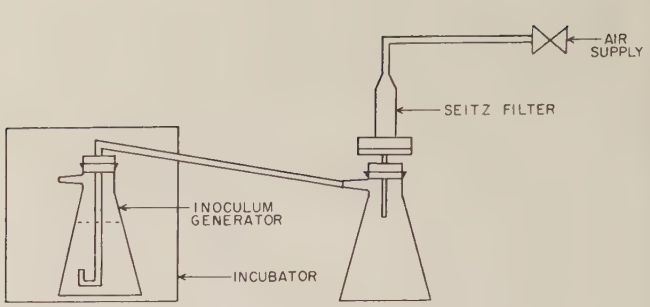

Fig. 2. Inoculation generator

recognized as an exacerbation to slime problems. Starch was added because it is a source of carbohydrate energy organically dissimilar from the groundwood, but common to the paper machine systems which were under investigation. The clay was included in the artificial media because of the fact that it is used in some of the paper machine systems with which we were concerned. Also, it could mechanically aid slime accretion by increasing the surface area within the forming mass.

This particular artificial furnish satisfied the general conditions with which we were concerned. Modification of this furnish might be required to reflect other manufacturing conditions (e.g., pH, chemical pulps or protein concentration).

Preparation of the Inoculum

The inoculum generator, Fig. 2, is furnished with 1 l. of the same artificial white water which is used for the evaluation. The generator is initially inoculated with approximately 10 g. of slime from the machine to be studied. The inoculated material is incubated

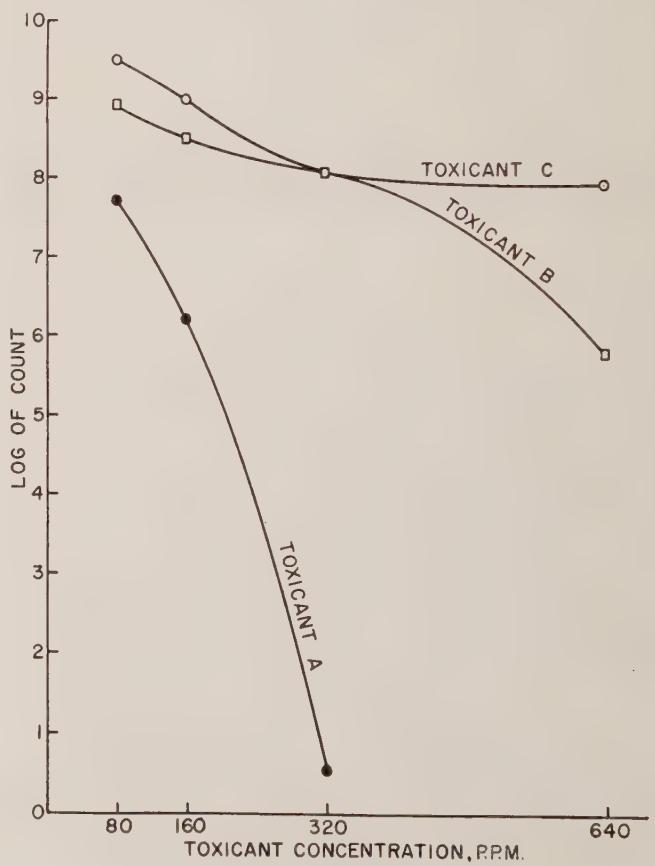

Fig. 3. Relative effectiveness of toxicants A, B, and C

for 24 hr. at paper machine temperature before it is used to inoculate the slime board apparatus. A residual of 100 ml. is always left in the generator in order to continue the inoculum. The generator is recharged daily with the artificial white water, and this cycle continues until the evaluation of the individual machine has been completed.

Operation of the Laboratory Slime Board Apparatus

Eight liters of fresh, artificial white water are put into the slime board apparatus daily. Correspondingly, the system is inoculated daily with 900 ml. of material from the inoculation generator and the temperature control is adjusted so that the temperature of the circulating white water will be the same as that of the machine under study. The artificial white water is allowed to circulate for 24 hr; the accretion is then collected from the boards and a plate count of this material is performed. The boards are washed with hot tap water and reinstalled in the apparatus which is recharged with 8 l. of artificial white water, and again set into operation. The plate counts are made on nutrient agar from dilutions ranging from 1:10 up to 1:-1,000,000 and are incubated at machine temperature for 48 hr. before being counted. Several runs are made with the apparatus in the absence of toxicants until the count becomes relatively constant. The count obtained at this time is considered as the control count. The operation continues for four consecutive days: on the first day 80 p.p.m. of toxicant is added, and the concentration is doubled on each consecutive day, which gives a final concentration of 640 p.p.m. All the data are presented in terms of the logarithm to the base 10 of the plate counts. The daily operation of the machine slime board apparatus involves washing the unit and the collection and plate counting of the accretion.

RESULTS

Laboratory Data Obtained for Toxicants A, B, and C

Figure 3 shows the laboratory data obtained for three toxicants. The logarithm of the control count for this situation was 8.9. Toxicant B represented somewhat of a control situation to us since we had been using the product throughout the mill for several years. Although the exact meaning of these data remains somewhat obscure, it is obvious that under the conditions of this test, toxicant A is more effective than toxicant B, which in turn is superior to toxicant C. Notice that at 80 p.p.m. of toxicant B was at the same bacterial level as the control, and that toxicant C had a count which was even higher than control. Toxicant A at 320 p.p.m. lowered the bacterial level to a value which was less than 10 cells per gram. Therefore, the point was arbitrarily placed between 1 and 0 since the actual count at this level was insignificant and difficult to determine accurately.

Slime Board Data from the Paper Machine

Table I shows bacterial count averages multiplied by 10^6 for periods in which toxicants A, B, and C were used. All three of these periods were on the same machine. The approximate durations of these periods were 3 months, 7 weeks, and 6 weeks, for toxicants A, B, and C, respectively. The principal observation here is that the toxicant which was best, according to the laboratory evaluation, was the most effective when applied to the paper machine. Also notice that in addition to the lower average count, for the toxicant A treatment, the cost per ton was 16% less. The least effective according to laboratory tests—toxicant C—gave a slightly lower machine count than toxicant B but at a cost increase of 38%.

Table 1. Bacterial data from paper machine slime boards

Toxicant	*Av. bacterial count* $\times 10^6$	*Relative cost, %*
A	3.1	84
B	34.5	100
C	24.3	138

Other Observations Made on the Paper Machine

During the periods that toxicants B and C were used, the machine trays would become slimy within a week after a boilout. The trays remained clean for the duration of the A toxicant treatment. The wet-end downtime during the B and C treatment was considered normal for the machine. However, the usual wet-end downtime figure was reduced by 44% during the toxicant A treatment.

DISCUSSION

The toxicant concentrations used in the laboratory work are higher than that which is generally considered applicable; especially when the dosage is compared to the volume of the machine system. However, when a toxicant is applied to the paper machine as a slug treatment, and compared to the incoming flow rate, the 80- to 160-p.p.m. range is not too unreasonable. When the machine under study was on toxicant B, the slug concentration on this basis ranged from 90 to 120 p.p.m.

The reproducibility of results for this method has not been determined under the exact laboratory conditions previously described. However, toxicants A and B have been run on two other occasions with furnishes similar to the artificial medium and the resulting curves were characteristic of the ones obtained with the artificial white water.

Concerning future applications of this method it is expected that the data from the machine slime board might be a useful indicator as to when the current toxicant has become less effective. Hence, a repeat of the laboratory procedure should indicate the toxicant which would give the best alternating treatment. The work to date indicates also that changes in the microflora involving a shift from bacterial types of mycelial types can be detected in the plate counts. In this connection it should be mentioned that fungal counts which are lower than the usual bacterial counts can be indicative of a severe condition. This idea is somewhat confirmed by the fact that the growth-time requirement (generation time) is considerably greater for the fungal types than it is for the bacterial types.

Although any conclusions made on the basis of three trials are of limited value, it is expected that this method is capable of being instrumental in establishing a successful and economical slime control program.

Received Mar. 15, 1960. Presented at the 45th Annual Meeting of the Technical Association of the Pulp and Paper Industry, held in New York, N. Y., Feb. 22-25, 1960.

Concora Instrumentation Studies

II. Relationships Between Tensile, Tear and Mullen

G. G. MALTENFORT

In the Concora Instrumentation Study—I (3), the author described a new test, called the Concora torsion tear test. In this second study, the relationship between conventional tensile and tear and Concora torsion tear, and the Mullen test is the subject of a statistical correlation analysis. Simple and multiple regression equations together with correlation coefficients and standard errors of estimate are given for kraft and cylinder liners used in the manufacture of corrugated and solid fiber boxes. Partial regression coefficients are used to elucidate further the nature of these relationships.

For many years the Mullen test has been a universally accepted test criterion for evaluating the quality of shipping container liner grades, and corrugated and solid fiber boards. It appears in almost all packaging specifications, be they of the manufacturing, purchase, government, or freight rule type. Nevertheless one continues to encounter the question: What is the "quality" that the Mullen test really measures?* It is one purpose of this paper to answer this question.

In addition to the discussion of the relationships existing in general between tensile, tear and Mullen, comparisons between Concora torsion tear and Elmendorf tear are shown.

DISCUSSION

Background Information

The prevailing belief that Mullen is a wholly arbitrary test is difficult to account for, in view of the considerable work done in the past which shows the burst test to be a means for measuring fundamental paper characteristics. As far back as 1938, an excellent paper was published by Van den Akker (*1*) showing that the bursting strength of paper is a function of the radius of the orifice in the bursting strength tester, the radius of curvature of the bulge, the tensile force per unit dimension of the paper, and its extensibility or stretch per unit length.

In another study published by the Institute of Paper Chemistry in 1944 (*2*), the observed tearing force was shown to depend on the average value of the work required to rupture a fiber in a mesh, the average work required to drag a fiber from such a mesh, the total number of fibers involved in the tear, and the number of fibers dragged intact from such a mesh. In the same study the relationship between tear and Mullen was shown to be nonlinear with respect to beating time. There are thus a variety of ways in which refining, fiber length, and fiber bending can affect tear and Mullen.

In this study we are not concerned with fiber preparation or any other papermaking process. Instead, we have examined, by means of correlation techniques, the interrelationships between Mullen, tear and tensile on randomly selected typical liner grades. Presumably each mill has established what combination of furnish and fiber preparation is necessary to produce sheets with optimum properties. Undoubtedly the relationships established here would or could be changed if changes in the nature of the fibers or their preparation were made. Our intent was to show only that the Mullen or burst test *is* indicative of fundamental paper characteristics, and is not as some believe a purely arbitrary test devoid of meaning.

Comparison of Concora Torsion Tear and Elmendorf Tear

As is to be expected, both tear test methods are highly correlated to each other. This association between the two test methods is affected by the problem of screening diagonal tears, however. On cylinder liner grades, where it is very difficult to obtain proper cross-directional tear values with the Elmendorf test (*3*), the correlation between the two test methods is not as good as it is in the machine direction or with kraft liner grades.

EXPERIMENT AND DATA ANALYSIS

The data in this experiment consists of the same 343 sets of kraft liner grades from 26 to 90 lb. per M sq. ft. and 145 sets of cylinder liner grades from 38 to 110 lb. per M sq. ft. already described in the Concora Instrumentation Study I (*3*).

On each liner sample an average of one Mullen burst up and one down was compared to a single machine direction (MD) and opposite direction (OD) tensile and MD and OD tear test taken out of the same sheet. Tear tests were made on the Elmendorf as well as the Concora torsion tear tester (*3*). Tensile data were obtained on a conventional Thwing Albert. All tests were made in accordance with TAPPI Standards, except Concora torsion tear where the CCA method was used, being the only existing procedure at present. All tests were on conditioned samples, in accordance with TAPPI Standard T 402-m-49 in an atmosphere of 73°F., 50% R.H.

For the sake of brevity we show only four scatter diagrams, (Figs 1–4): OD Concora torsion tear and MD Thwing Albert tensile are plotted against Mullen, on cylinder and kraft liner grades.

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* The following answer to a reader's question published in *Modern Packaging* 33, No. 6: p. 134 (Feb., 1960) serves to illustrate this state of confusion: "Over the years the paper industry found that this burst or Mullen value is an index of paper performance for certain end uses. However, there is still considerable debate as to what this test means, since it does not measure or define a fundamental property as compared with a test for tensile, tear, stiffness, or other basic single property."

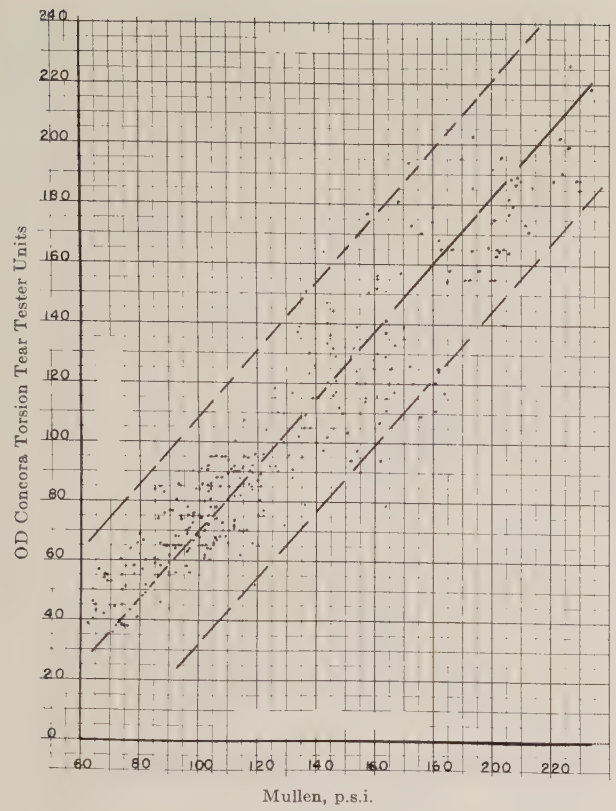

Fig. 1. OD Concora torsion tear vs. Mullen kraft

The relationships between liner Mullen and tensile and tear and those between Concora torsion and Elmendorf tear are summarized in the estimating equations given in Tables I to III.

Several important facts emerge from these relationships:

(a) There is a very high correlation between all of the basic tensile and tear tests, regardless of test direction (paper orientation) and Mullen. The limits

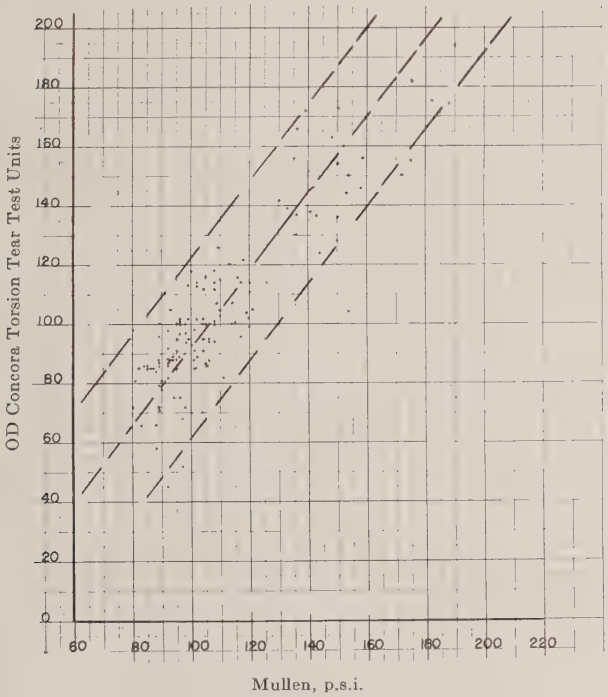

Fig. 2. OD Concora torsion tear vs. Mullen cylinder

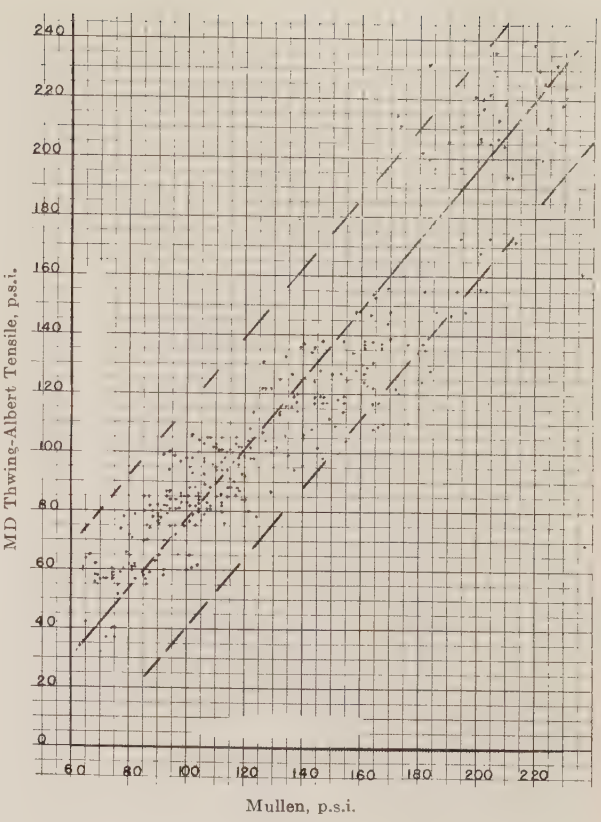

Fig. 3. MD Thwing-Albert tensile vs. Mullen kraft

within which 95% of the data fall (±2 × std. error) are fairly wide, both for individual test and averages based on five tests. This is to be expected, since within

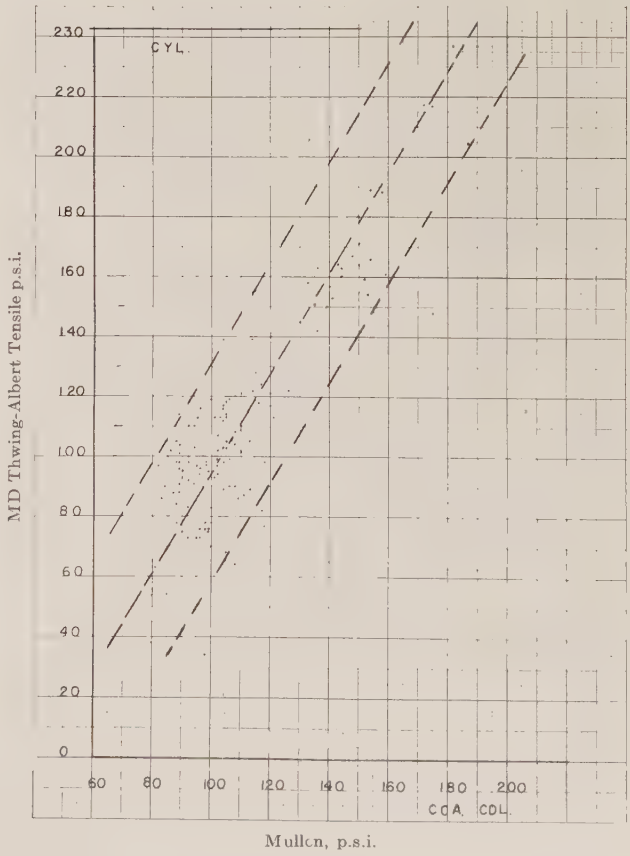

Fig. 4. MD Thwing-Albert Tensile vs. Mullen cylinder

Table I. Relationships to Mullen, Kraft Liners

Equation	Correlation coefficient	±2X Std. error (Individual), p.s.i.	±2X Std. error (Av. n = 5), p.s.i.
Mullen[a] as a Function of One Variable, M_1			
$M_1 = 51.76 + 0.146 \times$ OD Elmendorf tear	+0.937	29.3	13.1
$M_1 = 38.33 + 0.888 \times$ OD Concora torsion tear	+0.913	34.3	15.3
$M_1 = 31.71 + 1.863 \times$ OD T. A.[b] tensile	+0.926	31.6	14.1
$M_1 = 49.06 + 0.179 \times$ MD Elmendorf tear	+0.898	37.0	16.5
$M_1 = 50.38 + 0.950 \times$ MD Concora torsion tear	+0.921	32.6	14.6
$M_1 = 34.38 + 0.854$ MD T. A. tensile	+0.927	31.5	14.1
Mullen as a Function of Two Variables, M_2			
$M_2 = 5.64 + 0.51 \times$ OD Elmendorf tear + $0.874 \times$ MD T. A. tensile	0.989	12.4	5.5
$M_2 = 5.07 + 0.47 \times$ OD Elmendorf tear + $1.91 \times$ OD T. A. tensile	0.990	11.9	5.3
$M_2 = 4.68 + 0.407 \times$ OD Concora torsion tear + $0.753 \times$ MD T. A. tensile	0.990	11.8	5.3

[a] Mullen in p.s.i.
[b] T.A. = Thwing Albert Model 35–4, pendulum type, 0–500 lb.

Table II. Relationships to Mullen, Cylinder Liner

Equation	Correlation coefficient	±2X Std. error (individual), p.s.i.	±2X Std. ereor (Av. n = 5), p.s.i.
Mullen as a Function of One Variable, M_1			
$M_1 = 51.21 + 0.165 \times$ OD Elmendorf tear	+0.835	26.8	11.9
$M_1 = 29.76 + 0.764 \times$ OD Concora torsion tear	+0.882	23.0	10.3
$M_1 = 3.59 + 3.481 \times$ OD T. A. tensile	+0.854	25.4	11.4
$M_1 = 56.19 + 0.260 \times$ MD Elmendorf tear	+0.870	31.2	14.0
$M_1 = 59.67 + 1.350 \times$ MD Concora torsion tear	+0.917	19.0	8.5
$M_1 = 42.99 + 0.600 \times$ MD T. A. tensile	+0.893	21.9	9.8
Mullen as a Function of Two Variables, M_2			
$M_2 = 0.463 + 0.0463 \times$ OD Elmendorf tear + $3.0397 \times$ OD T. A. tensile	0.994	5.26	2.35
$M_2 = 4.28 + 0.383 \times$ OD Concora torsion tear + $0.815 \times$ MD T. A. tensile	0.989	7.2	3.2

Table III. Relationships Between Concora Torsion Tear and Elmendorf Tear

Estimating equation	Correlation coefficient	±2X Std. error (Individual), g.	±2X Std. error (Av. n = 5), g.
Kraft			
OD Elmendorf tear = $5.6 \times$ OD Concora torsion tear -42.67	+0.897	238	106
MD Elmendorf tear = $4.63 \times$ MD Concora torsion tear $+61.93$	+0.897	186	83
Cylinder			
OD Elmendorf tear = $3.17 \times$ OD Concora torsion tear $+25.4$	+0.721	171	76
MD Elmendorf tear = $4.62 \times$ MD Concora torsion tear $+35.77$	+0.933	59	26

any given type of liner, samples chosen from progressively heavier and stronger sheets would reflect these ascending strength properties, regardless of what strength test is chosen, whether this be Mullen, tensile, or tear. This fact alone is not, therefore, what is most significant.

(b) When a tensile *and* tear test is combined to give an estimate of Mullen, the correlation is considerably improved to give very nearly perfect correlation coefficients. Furthermore, the error with which Mullen is now estimated is very small, in fact it is well within the limits of error of the test itself. This fact is very significant.

(c) An analysis of the partial regression coefficients is also very enlightening. The coefficients tell us to what extent each of the independent variables is related to the dependent variable with the effect of the other variable(s) eliminated. Thus when we get a correlation coefficient between Mullen and OD Concora torsion tear of +0.937, a fair portion of this association is attributable to the intercorrelation of tear to tensile, i.e., tensile and tear are not really independent of each other and when we relate either of them to Mullen, which is a combination of both, the simple regression between Mullen and tensile reflects also in part the relationship of Mullen to tear.

On kraft liners some of these partial regression coefficients turn out as follows:

Correlation of Mullen to:

OD Concora torsion tear, OD Tensile *excluded:*	+0.6137	OD Elmendorf tear, OD Tensile *excluded:*	+0.5865
OD Thwing Albert tensile, OD Concora torsion tear *excluded:*	+0.6839	OD Thwing Albert tensile, OD Elmendorf tear *excluded:*	+0.5883
OD Concora torsion tear, MD Tensile *excluded:*	+0.5200	OD Elmendorf tear, MD Tensile *excluded:*	+0.4928
MD Thwing Albert Tensile, OD Concora Torsion tear *excluded:*	+0.6208	MD Thwing Albert tensile, OD Elmendorf tear *excluded:*	+0.4820

Other combinations of tensile and tear tests to estimate Mullen could be used, and the same can be done for cylinder liners. All of these partial regression coefficients then turn out to be of the same order of magnitude, averaging around +0.494.

The importance of this outcome derives from two facts:

Just as there is an intercorrelation between tensile and tear, so too a strength test made in the OD direction is intercorrelated to the same test made in the MD direction.

(2) The square of a regression coefficient multiplied by 100 gives the per cent of the variation explained by the association of the variables.

Pursuing this argument, and using for the sake of brevity and simplicity the mean partials for each association, we have:

OD tear to Mullen, +0.494
MD tear to Mullen, +0.494
OD tensile to Mullen, +0.494
MD tensile to Mullen, +0.494

$4 \times (0.494)^2 \times 100 = 97.6\%$, total variation accounted for.

This compares to the multiple correlation coefficient of $(0.99)^2 \times 100 = 98.0\%$.

Clear proof is thus established that Mullen is a function of both tensile and tear, measuring both of these properties simultaneously. The intuitive realization that this must be so is thus amply supported by experimental evidence and accounts for the fact that this test has maintained its place in the field of specifications. On liners one could conceivably dispense with Mullen and use tensile and tear instead, but this cannot be conveniently done on combined boards. The major advantage of burst is therefore that it is a practical single measure of both tensile and tear, which can be used equally well on components and combined boards. This statement implies of course that due regard is paid to careful control of the many variables inherent in burst testing. Problems involving such controls are many and they have been discussed in the literature. Suffice it to say that if these variables are carefully controlled, the conclusions in this study are valid.

(d) As previously noted, all of the above described tensile data were obtained on a pendulum type Thwing Albert Model 35–4. Other type tensile testers, of which there are quite a few, would undoubtedly give estimating equations and lines of best fit which are different from those listed above. To the extent that each instrument measures the basic property of tensile, the same fundamental relationships and correlations would be confirmed which are described here.

CONCLUSIONS

1. The Mullen test measures a combination of tensile and tear.
2. The bursting strength of a liner can be predicted within small error limits from a knowledge of that liner's tensile and tear strength.
3. Concora torsion tear and Elmendorf tear are equally suitable for use as the tear variable in estimating bursting strength, provided that it is possible to properly screen the Elmendorf tear data.

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RECEIVED April 25, 1960.

Fault Analysis and Relay Settings on Paper Mill Power Systems

C. S. MYERS and S. A. BOBE

This paper reviews the problems of proper relay settings for protection of paper mill distribution systems. It includes examples of coordination methods between relays, fuses, overload relays, and direct acting or series trips as encountered in the usual paper mill system. The importance of short circuit calculations is brought out and a sample calculation for a typical mill is given. The various types of paper mill feeder circuits are individually analyzed as to type of load, possible types of faults, and the necessary relay settings for best protection and coordination. Coordinating curves are made up to illustrate the zones of each protective device. Power generator protection and grounding is briefly reviewed and the latest practice relay equipment and methods outlined.

THE function of protective relaying connected in any power system is to protect power service from interruption and to prevent or limit damage to equipment. This is especially important in a paper mill which has more than normal exposure for electrical trouble, including dampness, water, salt cake, overhead pump lines exposed to lightning, and frequent overloading of equipment. Unnecessary dropping of loaded feeder circuits must be avoided as it may result in a paper machine or mill shutdown. With the large investment in modern mills, management demands minimum outage of electrical circuits. Cost of downtime easily justifies the best in protective equipment and practices.

FAULT INDICATION

Circuit breakers controlled by relays are used to interrupt current when a fault occurs on important circuits of all power systems. Fuses are sometimes used but have a number of limitations including nonadjustable time current curves. The system engineer should provide relays with proper selective settings such that only the local area of a fault is removed or isolated. This means that the relays will locate the fault and trip only the breakers or circuits directly connected to the faulted equipment. Relays are said to be selective when, by proper application and setting, they trip only the required minimum of circuit breakers to isolate the fault.

From this it can be seen that in order to apply and set protective relays on a power system, a knowledge of the system performance during faults is necessary. Relays must differentiate between permissible operating conditions and abnormal or fault conditions. The more common of these fault characteristics are: (1) ground current, (2) increased current in one or more phases flowing toward a fault, (3) reduced voltage of one or more phases with the lowest value being at the fault, and (4) temperature rise in the electrical equipment.

TRIPPING DEVICES

Devices used on paper mill power systems to detect or isolate fault conditions include: fuses, instantaneous direct acting (series) trips, time delay direct acting trips, thermal magnetic trips, and relays.

Fuses are used in both low and high voltage circuits. In coordinating them into a system, it must be remembered that their time-current characteristic is nonadjustable. It is necessary to use the manufacturer's

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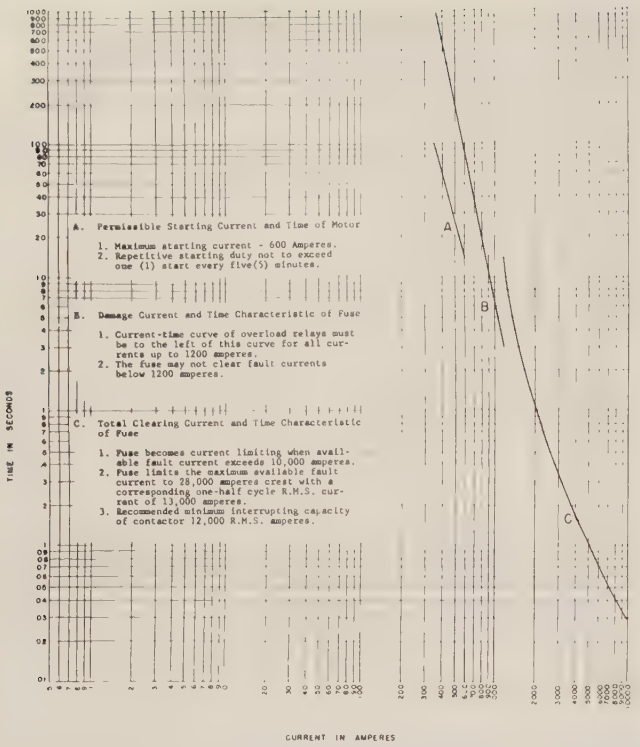
A. Permissible Starting Current and Time of Motor
1. Maximum starting current - 600 Amperes.
2. Repetitive starting duty not to exceed one (1) start every five(5) minutes.
B. Damage Current and Time Characteristic of Fuse
1. Current-time curve of overload relays must be to the left of this curve for all currents up to 1200 amperes.
2. The fuse may not clear fault currents below 1200 amperes.
C. Total Clearing Current and Time Characteristic of Fuse
1. Fuse becomes current limiting when available fault current exceeds 10,000 amperes.
2. Fuse limits the maximum available fault current to 28,000 amperes crest with a corresponding one-half cycle R.M.S. current of 13,000 amperes.
3. Recommended minimum interrupting capacity of contactor 12,000 R.M.S. amperes.
A
B
C
TIME IN SECONDS
CURRENT IN AMPERES

Fig. 1. Typical motor starting fuse time current curve

time current curves (Fig. 1) since these vary with different makes. As a general rule, fuses may vary $\pm 10\%$ in current for the same melting time and $+20$ and -0% current for the same clearing time.

Instantaneous, direct acting trips or series coil trips, are not exactly instantaneous but are considered as such for coordinating purposes. Some of these devices have adjustable current pickup.

Time-delay direct acting trips can be adjusted for current pickup in the same manner as instantaneous trips. The time delay may be obtained by liquid filled or air dashpots, an escapement mechanism timer, an oil film timer, or a thermal trip.

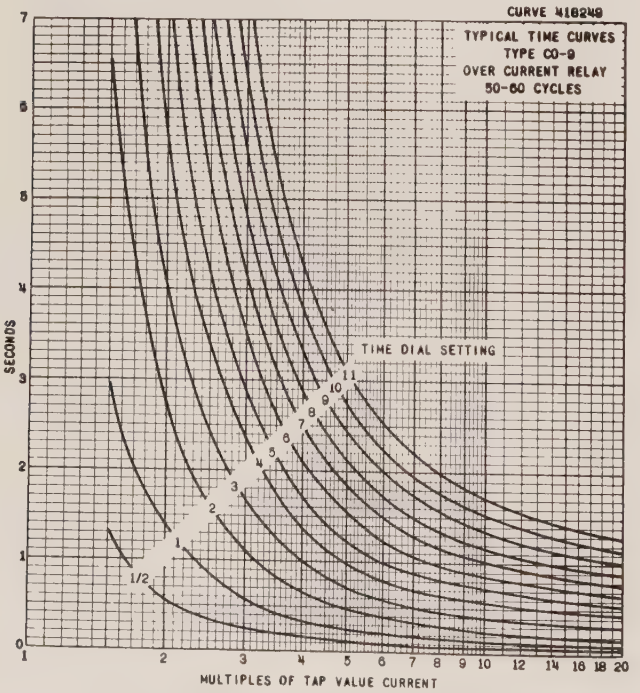

Fig. 2. Time current curves for induction overcurrent relay

Thermal magnetic trips depend on a thermal device for their time delay operation and are used primarily in conventional low voltage air circuit breakers. These breakers normally also include an instantaneous magnetic trip.

Relays are the basic method for controlling high voltage switchgear and in some cases low voltage breakers. Induction-type relays are the more common type with many variations, including different degrees of their inverse time characteristics which gives short operating time on large currents and proportionately much longer operating time as the current decreases. They may be used as differential or ground relays and may include an instantaneous attachment of a plunger-type relay for fast action on severe faults. The operating coils have several current range taps which are adjustable by means of a tap plug. The time setting is adjusted by means of a dial or lever which varies the distance the disk has to travel to close the relay contacts. A family of curves is shown in Fig. 2.

To illustrate the use of these curves, let us assume a 500/5 current transformer (CT) ratio, a 5000-amp. fault current, and relays set on the 10-amp. tap and no. 2 time dial setting. In this case there would be 50 amp. in the CT secondary with the 5000 amp. fault, or 5 times the 10-amp. relay pickup setting. Referring to Fig 2, 50 amp. corresponds to a reading of 5 on the abscissa or "multiples of tap value current." Proceeding vertically to the curve marked 2 "time dial setting," 0.48 sec. relay operating time is shown. To this the circuit breaker operating time must be added to determine total time to open the circuit.

DATA REQUIRED FOR RELAY SETTING STUDY

In order to proceed with a relay study, it is necessary to have the following data:

1. A single line diagram of the system.
2. List of protective devices and their associated instrument transformers, with ratios.
3. List of all rotating machines and transformers, with their impedances, and connections.
4. List of major feeders giving size, length of conductor, and connected horsepower.
5. Maximum and minimum values of short circuit current as calculated from the above data.
6. Starting currents and accelerating time of large motors that may affect breaker settings.
7. Characteristic curves of tripping devices, relays, and fuses used.
8. Any special conditions dictated by size of or condition of equipment.

SHORT CIRCUIT CURRENT CALCULATIONS

This paper will only briefly review short circuit calculations as this subject is thoroughly covered by many publications and a simple review is usually sufficient for most paper mill studies.

The magnitude of short circuit current is determined by the amount contributed by the power generators and all rotating machines, both synchronous and induction, connected to the power system. To this must be added the contribution from any power company ties if synchronized with the mill system. The trend in newer paper mills is to isolate their power system and even if power is purchased, it is fed to a separate section

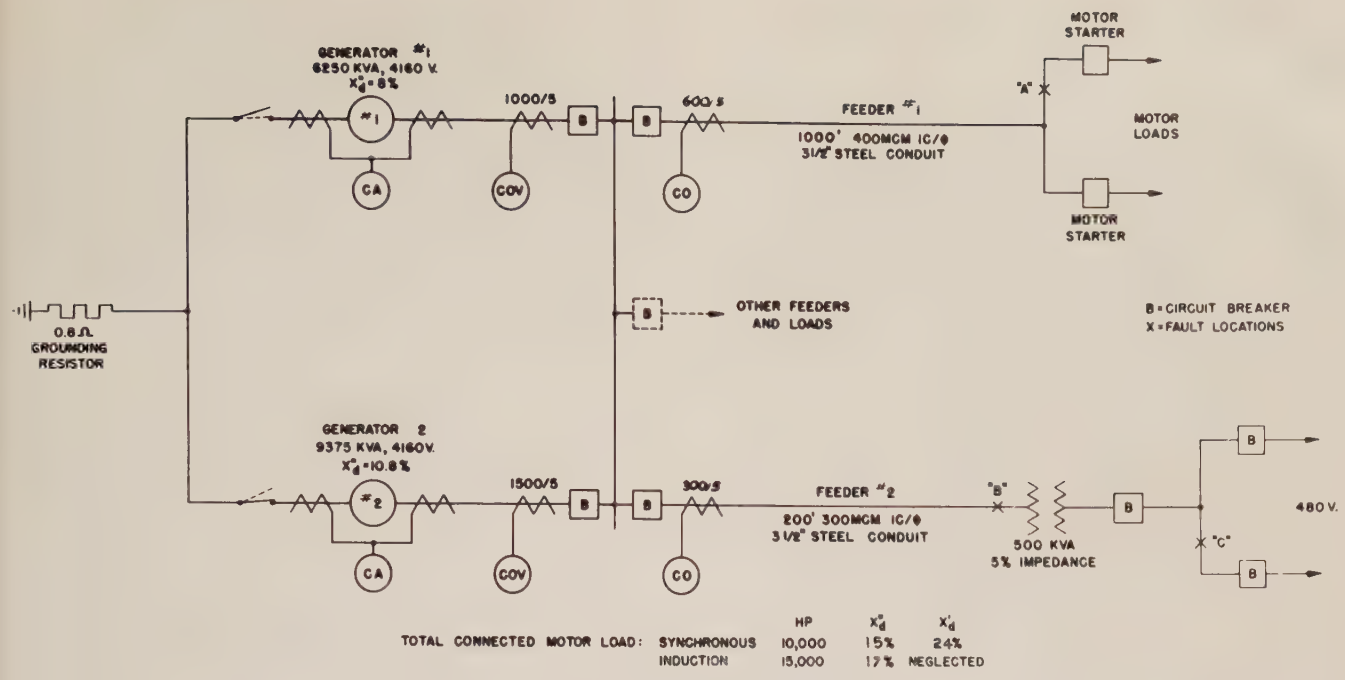

Fig. 3. System diagram

of load without synchronizing with the mill system. This subject of ties with power company systems is covered in an AIEE paper, no. 54–243, by Rose and Springer published in *Electrical Engineering Transactions*, September, 1954.

Two short circuit conditions must be considered in applying circuit breakers:

1. *Momentary rating* of the breaker must be equal to or greater than the highest r.m.s. value of current that the system can produce through the breaker in question.

2. *The interrupting rating* of the breaker must be equal to or greater than the short circuit current at the time of contact separation.

To obtain the *momentary current*, it is necessary to add the subtransient fault current of all synchronous generators and synchronous and induction motors that may feed the fault through the breaker. This current is then multiplied by a factor of 1.6 to take care of the asymmetrical or displaced current peak which may occur during the first few cycles.

The generator contribution is obtained by dividing the generator full load current by the generator subtransient reactance, X_d''. For 3600 r.p.m. turbogenerators, this will vary from 7 to 14% with a mean of 9%.

Synchronous motor subtransient reactance will vary from 13 to 35% or an average of 15%. The motor full load current divided by this factor will give its contribution to the fault.

Induction motors above 600 v. have a subtransient reactance which will vary from 15 to 25% with the figure of 17% generally being used.

Interrupting rating is obtained by using the subtransient (X_d'') contribution of generators and the transient (X_d') contribution of the synchronous motors. Since induction motors have no separate source of excitation, their contribution to a fault is essentially zero at the time of breaker contact opening. The synchronous motor portion is determined by dividing the motor rated current by the transient reactance which varies from 20 to 50% or an average of 24%.

The sum of the generator and synchronous motor currents gives the interrupting current. An offset multiplier is not required since paper mill circuit breakers are not likely to operate in less than 5 cycles.

The above described calculations give fault currents on the power house bus and are the largest that will be obtained on the system. Impedances between the machines and switchgear are not included since these runs are very short in most mills. For faults in the mill, however, the impedance of the cables must be considered, which will reduce these maximum values.

FAULT CALCULATION EXAMPLE

Probably an example of fault current calculations on a typical system will better explain the procedure that is usually followed. Figure 3 shows the system selected with two generators, and several feeders going out from the generator bus. In this example, however, only two feeders are shown, one distributing power at generator voltage, and the other using step-down transformers to 480 v. for utilization. Machine ratings, impedances, C. T. ratios, cable size and lengths, motor loads, etc., are shown on the sketch.

The first thing that is usually done is to calculate the maximum *momentary current* for a fault on the generator bus, or on one of the feeder circuits immediately adjacent to the bus. As explained previously, both the generators and all the synchronous and induction motors contribute to the momentary fault calculations and must be considered. The following calculations show how equivalent impedance of the generators is found and also equivalent impedance of the synchronous and induction motors, and how they are combined to obtain an equivalent system impedance. This equivalent system impedance is then used to calculate the momentary fault current. It should be noted that the current calculated is then increased by a factor of 1.6 which is used to take into consideration

the possibility of having a total offset or asymmetrical wave.

There are three systems that can be used for expressing the reactance of the elements used in calculating fault currents. They are (1) ohms, (2) per cent on a chosen kva. base, or (3) per unit on a chosen kva. base. As explained in the AIEE Publication no. 952 entitled "Electric Power Distribution for Industrial Plants," the per unit system is convenient to use with systems with different voltage levels, and as most paper mills fall into this category, it was used in this paper.

MAXIMUM MOMENTARY CURRENT

To change per cent impedance of machines to per unit, use the formula:

$$\text{Per unit reactance} = \frac{\text{per cent reactance}}{100}$$

Then, to change to the working kva. base, use formula:

$$\text{Per unit reactance on base kva.} = \text{per unit reactance on kva. rating} \times \frac{\text{base kva.}}{\text{kva. rating}}$$

The working kva. base selected is entirely arbitrary and for this example was chosen to be 100,000 kva., resulting in per unit values easy to work with.
At 4160 v.

$$\text{Per unit reactance} = \frac{(\text{ohms reactance})\ (100{,}000 \text{ kva. base})}{(4.16)^2\ \ (1000)} = (\text{ohms reactance})\ (5.76)$$

At 480 v.

$$\text{Per unit reactance} = \frac{(\text{ohms reactance})\ (100{,}000 \text{ kva. base})}{(0.480)^2\ (1000)} = (\text{ohms reactance})\ (434)$$

These multipliers will be used to simplify the conversion from ohmic to per unit values.

Generator no. 1

$$\text{Per unit reactance} = \frac{8}{100} = 0.08 \text{ on its own kva. base}$$

$$\text{Per unit reactance on 100,000 kva. base} = 0.08\,\frac{100{,}000}{6250} = j\ 1.28$$

Generator no. 2

$$\text{Per unit reactance} = \frac{10.8}{100} = 0.108 \text{ on its own kva. base}$$

$$\text{Per unit reactance on 100,000 kva. base} = 0.108 \times \frac{100{,}000}{9375} = j\ 1.15$$

For the equivalent impedance of both machines in parallel, use the formula:

$$\frac{X_1 X_2}{X_1 + X_2} = \frac{(1.28)\ (1.15)}{1.28 + 1.15} = j\ 0.61$$

Synchronous Motors

Assume horsepower of motors the same as kva. Then using the subtransient reactance value of 15% and repeating the calculation as for the generator above:

$$\text{Per unit reactance} = 0.15 \times \frac{100{,}000}{10{,}000} = j\ 1.5$$

Induction Motors

Assume horsepower of motors the same as kva. Then using the subtransient reactance value of 17%:

$$\text{Per unit reactance} = 0.17 \times \frac{100{,}000}{15{,}000} = j\ 1.13$$

The combined equivalent motor impedance becomes j 0.61. Combining this with the equivalent generator impedance of j 0.61, the system impedance becomes j 0.32. The cable impedances from the machines to the switchgear bus have been neglected as usually the distance, and therefore the impedance, is small. In mills when this is not the case, the impedance should be calculated and added directly to each machine impedance before they are combined to form the equivalent.

$$I \text{ momentary} = \frac{\text{Ep. u.} \times 1.6}{\text{Zq. u.}} = \frac{1.0 \times 1.6}{j\ 0.31} = 5.15 \text{ per unit}$$

$$\text{Per unit current} = \frac{\text{kva. base}}{\sqrt{3}\ \text{kv.}} = \frac{100{,}000}{\sqrt{3}\ 4.16} = 13{,}900 \text{ amp.}$$

$$I \text{ momentary} = 5.0 \times 13{,}900 = 71{,}600 \text{ amp.}$$

The next step is to calculate the maximum current which the breakers would have to interrupt with faults immediately adjacent to the generator bus. As explained previously, only the generators and synchronous motors are included in these calculations, and the following example shows that for the system selected, the maximum interrupting current comes out to be 27,300 symmetrical amp.

MAXIMUM INTERRUPTING CURRENT

Synchronous motors $X_d' = j\ 2.4$ per unit. The combined equivalent impedance of generators X_d'' and synchronous motors $X_d' = j\ 0.49$.

$$I \text{ interrupting} = \frac{1.0}{j\ 0.49} = 2.04 \text{ per unit.}$$

$$I \text{ interrupting} = 1.96 \times 13{,}900 = 28{,}400 \text{ amp.}$$

The next step to follow is to calculate the fault currents at the end of feeder no. 1 on the motor starter bus. This is done by adding the impedance of the feeder to the equivalent system impedance, and this current comes out to be 16,200 symmetrical amp. Similarly, fault currents at location B on feeder no. 2 were found, and then by adding the impedance of the 500 kva. step-down transformer, currents at location C were also calculated.

FEEDER FAULT CURRENT

Fault Location A

Feeder uses three 1/C 400 MCM cables in $3^1/_2$-in. steel conduit. Assume cable spacing of $1^1/_2$ in. From cable tables, impedance $Z = (0.03 + j\ 0.06)$ ohms per 1000 ft. This ohmic impedance at 4160 v. is changed to per unit impedance by multiplying by the 5.76 factor calculated previously and becomes $(0.173 + j\ 0.346)$ ohms for the 1000-ft cable length. Impedance to location A is the sum of the cable impedance and the equivalent system impedance at the high voltage bus (j 0.49 per unit) and equals $(0.173 + j\ 0.836)$ ohms.

$$I = \frac{1.0}{0.173 + j\ 0.856} = 1.17 \text{ per unit}$$

$$= 1.15 \times 13{,}900 = 16{,}200 \text{ amp.}$$

Fault Location B

Cable impedance = $(0.008 + j\ 0.013)$ ohms per 200 ft.

Table I. Tabulation of System Data

Breaker	*Feeder no. 1*	*Feeder no. 2*	*Generator no. 1*	*Generator no. 2*
C. T. Ratio	600/5	300/5	1000/5	1500/5
Cable size, MCM	400	300	...	...
Largest motor fuse	150LR600[a]	...	...	...
Av. load, amp.	310	100	870	1300
Conn. motor load, hp.	3263	853	...	...
Largest single mtr., hp.	450	250	...	...
Largest trans., kva.	...	500	...	...
Max. starting amp.	690[b]	280	...	...
Min. cable fault amps.[c]	16,200	24,600	...	...
Max. sec. fault amp.[d]	...	1320	...	...
Relay settings				
Tap	12	10	4	3
Lever	2	5	4	4
Instant	...	40	...	...
Voltage,[e] %	...	...	85	85

All currents shown are symmetrical on 4160-v. base.
[a] Indicates a fuse to be used with a motor having less-than 150 amp. running current and less than 600 amp. locked rotor.
[b] Including starting current of largest motor and running current of all other connected motors on feeder.
[c] At end of 4160-v. feeder.
[d] Fault current on 4160-v. system with fault on secondary side of largest step-down transformer.
[e] Used on COV relays for generator breakers only.

Cable impedance = $(0.046 + j\,0.075)$ per unit
Total impedance = $(0.046 + j\,0.565)$ per unit

Since the resistance part of total impedance is so small in relation to the reactance element, it can be neglected, resulting in an equivalent impedance of $j\,0.565$ per unit.

$$I = \frac{1.0}{j\,0.565} = 1.78 \text{ per unit}$$
$$= 1.7 \times 13{,}900 = 24{,}600 \text{ amp.}$$

Fault Location C

Transformer is 500 kva., three-phase, 4160 to 480 v., 5% impedance. This 5% impedance on its own 500 kva. base becomes j 10.0 per unit on the 100,000 kva. base selected. Total impedance to point C is then $j\,10.0 + j\,0.565$ or $j\,10.565$ per unit.

$$I = \frac{1.0}{j\,10.565} = 0.095 \text{ per unit}$$

Equivalent current on 4160-v. system = $0.095 \times 13{,}900 = 1320$ amps. Actual fault current on 480–v. system is found by multiplying 0.095 by per unit current on 480-v. system $(100{,}000/\sqrt{3}\ 0.48$ or 120,000 amp.) and equals 11,400 amp.

COORDINATION OF SYSTEM PROTECTIVE DEVICES

At this stage, it probably is desirable to tabulate the above values, and also other system data in a manner similar to that shown in Table I. This gives all the pertinent data required to plot time current curves for the various feeders, and to select the proper relay settings to get the best coordination.

A. Feeder with High Voltage Motors

Figure 5 shows the finished time current curves for feeder no. 1. In constructing such a graph, it is best to start off by labeling various values, such as the maximum starting current, ground fault current, minimum cable fault current, bus fault current, the time current characteristic of the largest motor fuse (in this case a 150LR600) and the cable damage curve (Fig. 4). From a review of these data, together with a study of the system diagram, it becomes obvious that the proper setting for the overcurrent relays on the main feeder breaker should fall somewhere between the curve for the fuse and the cable damage curve. In other words,

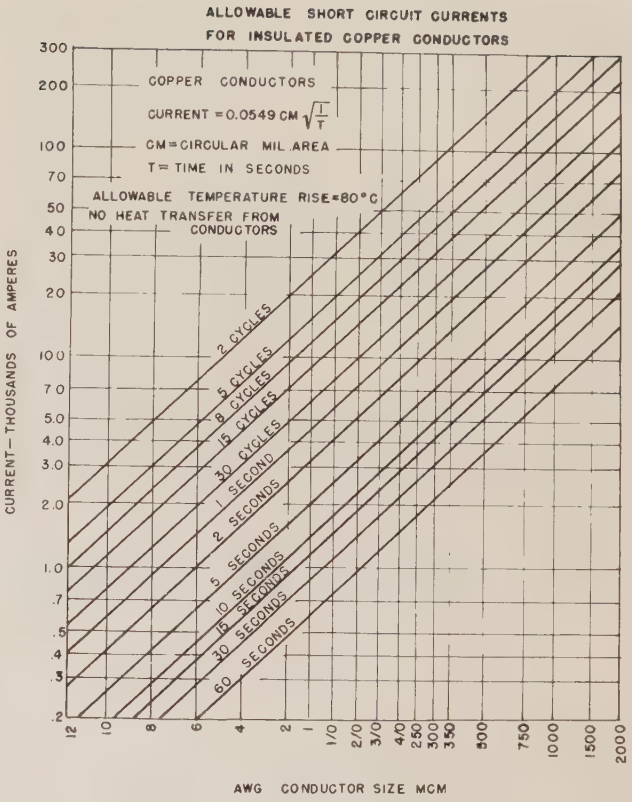

Fig. 4. Allowable short circuits currents for insulated copper conductors

the main feeder breaker should be fast enough in its operation to protect the cable from damage during fault conditions, but should not be so fast that it does not give the motor fuses a chance to operate in case the fault is on the load side of the fuses. It should also be able to detect ground faults, but not operate on starting currents.

In order to obtain a starting point, a minimum value of tripping current close to but above the fuse curve should be selected, and this current value, divided by the current transformer ratio, will give a tap setting for the overcurrent relay. Maximum fault amperes could be used as a starting point; however, proper co-

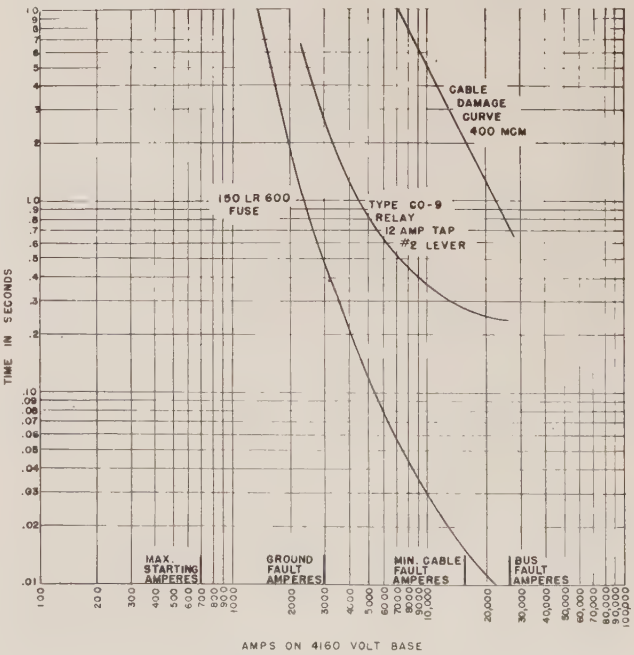
CABLE DAMAGE CURVE 400 MCM
150 LR 600 FUSE
TYPE CO-9 RELAY 12 AMP TAP #2 LEVER
MAX. STARTING AMPERES
GROUND FAULT AMPERES
MIN. CABLE FAULT AMPERES
BUS FAULT AMPERES
TIME IN SECONDS
AMPS ON 4160 VOLT BASE

Fig. 5. Coordination curves for feeder no. 1

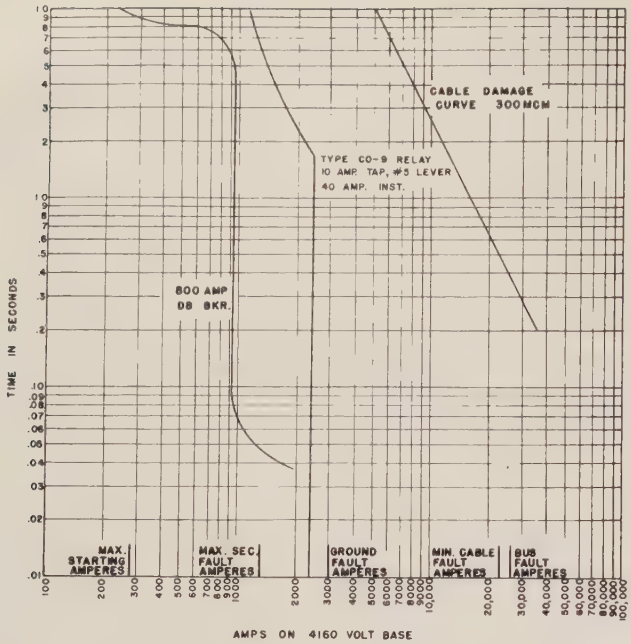

Fig. 6. Coordination curves for feeder no. 2

ordination is usually more difficult at the low value so this was used. For feeder no. 1, by referring to the upper part of the time current curve for the motor fuse (Fig. 1), a minimum value of about 1500 amp. fault current was selected, and this value, divided by the C. T. ratio of 120 (600/5) gives a tap setting of 12.5. The nearest available tap to 12.5 is 12 and that setting is used. From this point, reference should be made to the operating characteristics of the overcurrent relay being used, and for purposes of illustration, a Westinghouse very inverse relay, type CO-9, was used. By referring to the published literature on this relay, Fig. 2, it will be noted that curves are plotted with seconds on the ordinate and multiples of tap value current on the abscissa. Tap value current is equal to the tap setting selected times the current transformer ratio, and works out in this example to be 1440 amp. Many times in using the original formula, a tap setting which is not available on the relay is desired and compromises have to be made to the nearest available one.

Time current curves on overcurrent relays are not plotted below 1.5 times multiples of tap value current because operation of a relay below that point is unreliable, and no attempt to coordinate with other devices should be made in that area. Taking the 1440 amp. selected as the tap value current, and increasing it by 1.5 times, the curve is started at the 2160 amp. point. At this stage, a lever time setting must be selected, and by referring to the time current curve of the fuse, it was decided that at the 2250 amp. point approximately 6 sec. time delay would be sufficient. This corresponds to lever setting no. 2 with the 1.5 multiple of tap value current and it was, therefore, selected.

A word of caution should be injected at this point; for the same operating time the relay curve should always have at least a 25% higher current value than the fuse curve. This requirement has been satisfied in this particular case. It is also desirable to have about a two to one ratio as far as time is concerned between the breaker and fuse operation and this minimum requirement is also met with margin to spare.

In this particular case, the first tap setting and first lever setting seem to work out satisfactorily, but if, for any reason, the first curve did not "fit," other lever settings and tap settings can be selected to move the curve either up or down, or from left to right. Changing the lever setting to a higher one would move the curve up, while increasing the tap setting would move it to the right. Usually, however, one or two "trials" is all that is required to obtain a satisfactory curve, particularly after one becomes accustomed to the problem.

By referring to the proposed curve, it will be noted that it meets the basic requirements as outlined in the earlier part of the discussion. It is sensitive enough to detect the 3000 amp. of ground fault current obtained on the system, and is also far enough to the "right" that it will not trip out on maximum starting current on the feeder.

B. Feeder with Transformer Load

The curves for feeder no. 2 (Fig. 6) are drawn up in a similar manner. It was assumed that an 800-amp. type DB main air breaker was used on the secondary side of the 500 kva. step-down transformer. In plotting the time current characteristics of this breaker, its normal values of trip current have to be plotted as resultant currents on the 4160-v. system. In order to do this, the normal trip values at 480 v. should be multiplied by a factor of 480/4160 or 0.115. Normal instantaneous trip currents on these breakers run about 10 times their rating, or 8000 amp. secondary current for an 800-amp. breaker. Multiplying this 8000 amp. by the 0.115 factor, gives 925 amp. current on the 4160-v. system and it is this value that is plotted as the instantaneous trip current.

Here again, boundaries have been outlined between which the feeder breaker trip characteristics must lie, that is, between the equivalent curve of the secondary breaker, and the damage curve of the cable. Using the formula as before, and making an initial selection of 1000 amp. as the minimum closing current, this figure, when divided by the current transformer ratio of 60, (300/5), results in a tap setting of 16.7. The nearest setting available is 15, so this was used as the "trial" run, and when multiplied by the current transformer ratio of 60, gives a tap value current of 900 amp. This, when multiplied by the 1.5 factor to get into the usable range of the CO relay curve, places the first point of the curve to be plotted at the 1350 amp. location. Referring again to the curve of the DB breaker, it seems desirable to have the feeder breaker operate in about 5 to 6 sec. at 1350 amp. fault current. This calls for a tap setting of no. 2, and the curve would coordinate very well with the secondary breaker, but it does not meet one other basic requirement: that is, its safe minimum operating point is approximately the same as the maximum secondary fault current. It could not "back up" the DB breaker satisfactorily. It, therefore, is desirable to lower the minimum pickup value by going to a lower tap, and the no. 10 is tried next, resulting in a minimum tap value current of 600 amp. The first point on the curve is at the 900 amp. point, and no. 5 lever setting seems about right. This new curve not only coordinates with the DB breaker, but also has a low enough pickup value to detect heavy secondary faults.

SETTING OF INSTANTANEOUS ELEMENTS

The next problem to take up is the setting of the instantaneous element of this relay. The use of an instantaneous element is desirable where there is a wide variation in maximum and minimum fault current on a particular feeder. Because feeder no. 2 is relatively short, its own maximum and minimum fault currents lie very close together, but there is a wide spread between these currents and the currents resulting from a fault on the secondary side of the step-down transformer. It is, therefore, logical to allow the instantaneous trip element to operate for all 4160 v. feeder faults, and let the time element "back up" both the instantaneous trip and the secondary breaker. On feeder no. 1 the use of an instantaneous element was not desirable since there was not enough spread between the maximum and minimum currents to obtain reliable differentiation.

The thing to watch in setting the instantaneous element of a feeder is that it should not, under any conditions, operate for a secondary fault. With 1320 amp. current in the 4160-v. system from a secondary fault, a "boundary" to work from is established. This 1320 amp. is symmetrical current and it is possible to have it totally offset resulting in 1.6 times 1320 amp. or roughly 2100 amp. Since an instantaneous element can operate in about $^1/_2$ cycle, it will have to be set above this 2100 amp. offset current. An arbitrary value of 2400 amp. was selected, which, when divided by the current transformer ratio of 60, results in a 40 amp. setting. This setting also happens to be low enough to detect the 3000 amp. of ground fault current obtained on this system.

GENERATOR PROTECTION

One of the latest concepts in protection of generators is a voltage-controlled overcurrent relay. Before the development of this new relay, it was impractical to try to relay generator feeder breakers by the use of standard overcurrent relays. This limitation was due to the fact that in order for the generator breaker to coordinate with the various feeder breakers, it would have to have a relatively long time delay setting. Due to the inherent characteristics of synchronous machines, after a short circuit exists for several seconds, the magnitude of fault current approaches the full load current of the machine. This condition comes about primarily due to the demagnetization effect of the large, low power factor current flowing through the generator windings. Since the overcurrent relays would have to be set above load currents to prevent them from tripping out during normal operation, they might not be able to trip the machine from the line in case of bus faults, as by the time they would get a chance to operate, the current could have fallen off below their minimum pickup value. The voltage controlled overcurrent relay, known as the type COV, overcomes this difficulty by use of a standard overcurrent relay, controlled by a voltage relay. The voltage relay is set to operate at approximately 85% normal bus voltage, and the overcurrent element can, therefore, be set to operate at less than full load current for the machine. During normal operations, with 100% bus voltage, the voltage relay would prevent the overcurrent element from operating even though a current setting value below normal load current was used. On close in or bus faults, however, the bus voltage would fall below the 85% setting of the voltage relay, which would then allow the overcurrent element to operate at the reduced current available at the time delay necessary in order for the relay to coordinate with feeder relays.

The use of these relays will provide back-up protection to the feeder breakers and in case, for some reason, they do not operate properly, the generator breakers, after a suitable time delay will trip the machines off the bus and clear the trouble. This same condition would hold in case of bus faults, since for that condition, the generator breakers would be the only ones which would have a chance to operate.

The first requirement in arriving at settings for the voltage control overcurrent relay is to determine the contribution from each generator for a fault in the system. In order to break the total fault current down into current in each of the generators, the following method should be followed:

From previous data:

Generator no. 1 X_d'' $= X_1 = j\,0.128$ per unit
Generator no. 2 X_d'' $= X_2 = j\,0.115$ per unit

$$\text{Generator no. 1 current} = \frac{X_2}{X_1 + X_2} = \frac{0.115}{0.128 + 0.115}$$

$$= 47\% \text{ total current}$$

$$\text{Generator no. 2 current} = \frac{X_1}{X_1 + X_2} = \frac{0.128}{0.128 + 0.115}$$

$$= 53\% \text{ total current}$$

Thus it can be seen that machine no. 1 contributes 47% of the total current while machine no. 2 contributes 53%.

The next thing to do is to plot the operating characteristics of feeder breakers nos. 1 and 2 for faults on their load side. Figure 7 shows operating curves with amperes fault current on the abscissa and breaker operating time in seconds on the ordinate, and it will be noted that they are the same as shown in Figs. 5 and 6. For easy comparison purposes, it is desirable to plot the time current characteristics of generator breakers nos. 1 and 2 on the same graph but, since the currents through them are not the same as through the feeder breakers, some "juggling" of currents has to be done. Previous calculations showed that on system faults, generator no. 1 contributed 47% and generator no. 2 furnished 53% of the total current. Therefore, to get them on the same "base," the total fault current has to be proportioned to each generator breaker accordingly and the proper relay settings selected so that their operation time at their share of the current coordinates with a feeder breaker that handles the total current of both machines.

By referring to Fig. 7 and the curves of feeders nos. 1 and 2, select a value of minimum fault current for the initial trial setting of the generator breakers. A 2000 amp. fault setting seems a good place to begin and, multiplying this by the 0.47 distribution factor, generator no. 1 contributes 940 amp. to the total. Dividing this by the 200 : 1 current transformer ratio results in a tap setting of 4.7. The nearest standard tap is 5 amp. and this was tentatively selected. This 5 amp. tap setting results in a tap value current of 1000 amp. ($5 \times 200 : 1$) for generator breaker no. 1 and an equiva-

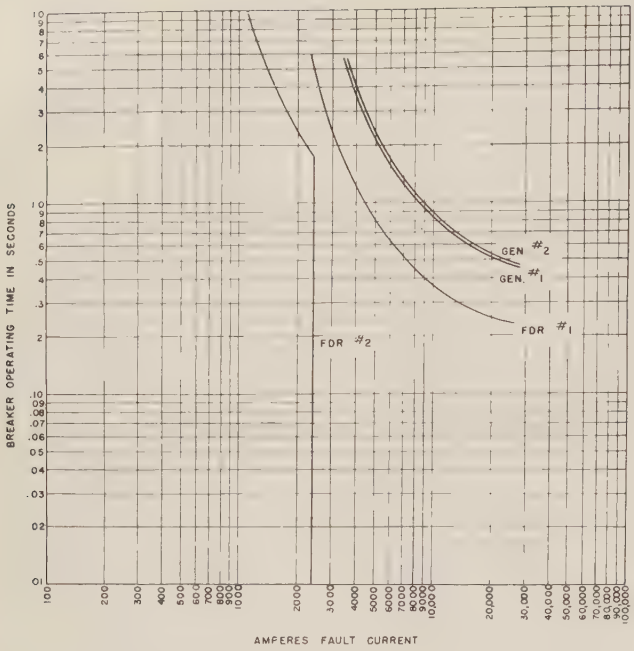

Fig. 7. Coordination curves for generator breakers

lent fault current of 2130 amp. (1000 × 1/0.47). In other words, with a fault current of 2130 amp., 1000 amp. would be contributed by machine no. 1.

Multiplying 2130 by the 1.5 ratio to be able to use the published relay data curves results in a current of 3200 amp. By referring to Fig. 7, a time in excess of the $2^1/_4$ sec. time of feeder no. 1 will be required. Since the overcurrent element of the COV relay is a CO element, Fig. 2 can be used to determine the proper lever setting and lever no. 2 setting was selected.

This point seems to coordinate fairly well, but to be sure that it "fits" throughout the curve, a point at 10 times normal current or 21,300 amp. was selected, resulting in a time of 0.25 sec. As will be noted, this point falls too close in time to the time current characteristic of the breaker on feeder no. 1, and a new start must be made. In order to maintain about the same point for 3000 amp., it appears desirable to decrease the tap setting, and increase the lever setting, and a new tap setting of 4 and a lever setting 4 results in the curve as shown, which coordinates very satisfactorily on the entire current range.

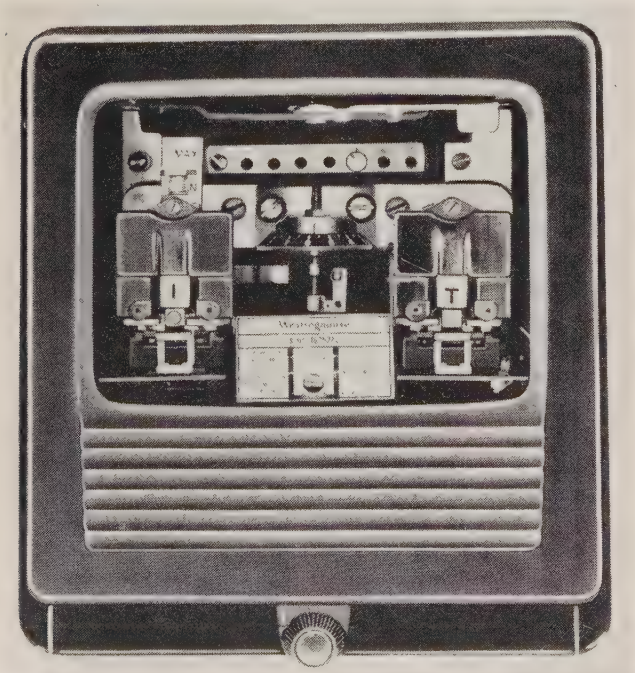

Fig. 8. Overcurrent induction relay-type CO-8

Following the same procedure, the curve shown for generator no. 2 was obtained by using tap no. 3 and lever no. 4. As explained previously, generally speaking a voltage setting of 85% is used.

Tap settings of 4 and 3 on generator breakers nos. 1 and 2, respectively, means that the minimum closing current of each is below their full load current rating. As discussed previously, however, the voltage element will not allow the overcurrent element to operate, unless the voltage drops below 85% of normal, and the only operating condition when this could occur would be for a close in fault.

There is no particular problem involved in setting the differential relays, as there are no taps in the setting to be made. Generally speaking 10% relays are used for generators in paper mills, meaning that the relay will operate to remove the machine from the line, in case there is a 10% differential of current between the current transformer in the neutral and the line current transformer in any of the three phases of the machine.

BUS PROTECTION

Additional bus protection may be provided by the use of bus differential relays which balance the incoming and outgoing currents to the bus. These relays can have high sensitivity since they do not recognize load currents. On modern metal-clad switchgear this added protection is not necessary because of the reliability of equipment. They are not shown in the example used.

GENERATOR GROUNDING

It is standard practice to design generating equipment to mechanically withstand a solid three-phase fault on the generator terminals. On most machines, however, the sequence impedances are such that if the machine is solidly grounded, the line-to-ground fault currents are larger than the three phase values and, therefore, the machine would be subjected to stresses beyond its normal design limits for that type fault. Various types of neutral grounding schemes can be used to limit this line-to-ground fault current, including reactors, resistors, and the distribution transformer-resistor scheme. In paper mills, however, the trend and practice is to go to resistance type grounding with a value of resistance used to limit the line-to-ground fault current to a value equal to or less than about 1.5 times the full load current of the machines. This relatively small value of current results in minimum equipment or system damage for line-to-ground faults, and is sufficiently large that reliable relaying can be obtained.

In selecting the value of ground fault current to be used on a system, it is necessary to consider the largest current transformer ratio used on any feeder. The value selected must be such that the phase overcurrent relays associated with this transformer will be able to reliably operate or "see" this ground fault current. In our example with a 1500/5 C. T. ratio on feeder no. 2, a value of 3000 amp. met this requirement.

FEEDER BREAKER GROUND RELAYS

Sometimes ground relays are also used on individual feeder breakers to give improved relaying for ground

faults. The ground relay can be set much more sensitive than a phase relay and, therefore, open the breaker faster in case of ground faults. Phase relays have to be set above the maximum load current on their particular feeders, while ground relays can be set to trip on currents considerably below normal load currents, resulting in much more sensitive relay protection.

This being the case, referring to feeder no. 1, a ground relay used on the feeder breaker would be unable to differentiate between a ground fault on the feeder itself or a ground fault in one of the motors. In a paper mill especially, it is desirable to maintain service to all of the motors, if possible, and it would certainly not be good practice to trip the feeder breaker out in case of a ground fault in one of the motors located on the 4160-v. bus. It, therefore, is not practical to use ground relaying on such a feeder where motors are supplied at the same voltage as the feeder voltage, and where a relatively large grounding resistor is used, resulting in practically uniform ground fault current throughout the system. The trend, however, is to provide individual ground protection at each high voltage motor starter by the use of through type current transformers. This is covered in more detail in the next section. Coordination of this ground relaying in the individual motor starter is automatically obtained by the low values used.

Feeder no. 2 presents a slightly different situation in that a ground relay, located on its feeder could not detect ground faults on the secondary side of the step-down transformer. However, on this particular feeder, we are obtaining good fast relaying for 3000 amp. faults, due to the setting of the instantaneous elements, and therefore a ground relay would not appreciably add to the overall protection on this feeder.

GROUND RELAYING

There have been a number of new trends in ground relaying which are being applied to paper mills. Most all station service and industrial power systems with voltages of 2300 v. and up are being resistance grounded. One method used limits the single line-to-ground fault current by a grounding resistor to a value in the order of maximum load current. Where this is done, it is generally possible to apply and set protective relays to obtain positive relay operation and adequate sensitivity.

More recently applications are being made of high resistance grounding where the single line-to-ground fault current is limited to a relatively low value (in the order of 100 amp.). Limiting ground fault currents to low values by high resistance grounding has the advantage of reducing the damage at the point of fault; however, the protective relaying used for the detection of low fault currents requires careful application and setting.

One method uses three current transformers with the secondaries of each having their individual phase relays, instruments, and meters connected in series after which the circuits are connected in parallel. The ground overcurrent relay is then connected in the common return. There will be no current flow through the ground relay during balanced load conditions or fault conditions that do not involve a ground. During a ground fault, or unbalanced line-to-neutral loads, a current flows in the ground relay. This relay can have a pickup setting as low as 10% of the full load current rating with a 0.5 amp. pickup rating being used. In setting ground fault detection this close, it is necessary to make certain that the low value of ground current necessary for relay operation will occur on the types and locations of ground faults for which the protection is provided. Some allowance must also be made for current transformer saturation. Another method used is similar to the above except that it employs a through type current transformer with all three power leads passing through the opening. An overcurrent relay is connected to the secondary winding. Because only one transformer is used, problems incurred by motor inrush currents and differences in current transformer saturation are eliminated. This scheme can, therefore, be made more sensitive and faster than the three-transformer one but is limited to cable circuits which can pass through the C. T. opening. This method is now becoming very widely used in individual high voltage motor starters to trip off the starter on a motor ground fault.

An instantaneous attachment may be used with the relay on either scheme to provide fast operation on large faults. This is especially desirable on motor protective circuits to limit damage to the motor and starter.

CONCLUSIONS

1. Increasing size of modern paper mill power systems makes it imperative that a system study be made to properly coordinate fault protection by relays, breakers, fuses, and other devices. On complex systems, it may be desirable to set up an equivalent system on a calculating board. This will save considerable time if it is desired to check a number of possible combinations.

2. This paper gives an example of procedure for making such a study on a typical simple system. Data needed for these calculations on apparatus and feeders should be accumulated and a file maintained for ready reference as changes or expansions are made in the mill system.

3. Relays should be tested at regular scheduled intervals of at least once a year to assure their operation when needed. Since paper mill atmospheres are corrosive, they may build up high contact resistance on relay "make" contacts which may prevent breaker tripping. Testing should be with a load box so that current energizes relay operating coils to make sure of complete relay operation. New Flexitest relays facilitate this as the units can be easily tested without disturbing any wiring.

4. A system study is not only useful for relay settings but also helps to determine available margin in existing breaker and feeder capacities. When making system changes, breaker ratings, both momentary and interrupting, should be carefully checked to be sure they are not exceeded by possible faults. Failure of a breaker to handle a fault may result in serious damage and downtime.

5. When increasing a system so larger amounts of power are available, feeder cables should also be checked for possible damage on a maximum fault. A table is included giving cable maximum fault capacities.

A Theory of Drying with Air

T. A. GARDNER

The operating principles of the new Gardner drier are explained, and the special features that make its use practical are emphasized. The rate of drying with air depends primarily on the phenomenon of boundary layer film. The particular arrangement of nozzles in the Gardner drier produces a thin laminar film wherein the heat and mass transfer coefficients depend on the square root of air velocity divided by continuum length. The nozzle arrangement utilizes this relation to secure unusually high drying rates without deleterious effects on the drying surface.

THE "Gardner" drier is a recent development in the use of air for drying the vaporizable constituents from a continuous web of material. The invention of this machine grew out of a study of the latest concepts of boundary layer theory and the related thermodynamic relations. A practical, mechanical design was developed to utilize these concepts with the result that much higher drying rates are possible than with previous driers. It may be presumed that in any type of air drier the condition of the air, such as its temperature and humidity, may be duplicated, and so the basic advantage of one type of drier over another lies primarily in the rate of heat transfer and the related mass transfer. Heat and mass transfer depend on boundary layer conditions and are affected by the design and operating characteristics of the drier. Several practical considerations must also be satisfied, such as uniformity of drying, physical effects on the product, and ease of operation and maintenance.

NOMENCLATURE

A = area of nozzle orifice, sq. ft.
a = constant replacing quantities related to internal state of gas
B = boundary layer thickness at distance x, ft.
C_p = specific heat of gas, B.t.u./lb.-°F.
D = orifice width, in.
E = percentage of nozzle throat velocity at distance Y from nozzles
F = dynamic force of jet, lb.
G = mass flow, $V\rho$, lb./hr.-sq.ft.
g = acceleration of gravity, ft./sec.^{2}
h_m = mean heat transfer coefficient, B.t.u./hr.-°F. sq. ft.
h_x = local heat transfer coefficient, B.t.u./hr.-°F. sq. ft.
L = continuum length, ft.
N_p = Prantl number, dimensionless
N_r = Reynolds number, dimensionless
n = constant to indicate proportionality
P = point or location
V = main stream velocity, ft./hr.
V_x = local stream velocity, ft./hr.
x = independent variable of distance on surface from origin of continuum, ft.
Y = distance from nozzle, in.
μ = absolute viscosity, lb./hr.-ft.
ρ = density, lb./cu. ft.

BOUNDARY LAYER THEORY

Wherever relative motion exists between a surface and surrounding gas, a boundary layer condition is developed. This condition was first studied by Prandtl (*1*) who initiated the boundary layer theory of today. Prandtl's hypothesis is that in a thin film of fluid close to the surface, a large velocity gradient may occur with zero velocity with respect to the surface at the surface and a large velocity at a small distance from the surface. The combination of large velocity gradient with the seemingly insignificant viscosity of gases results in viscous forces of appreciable magnitude. Some important deductions of the theory are: pressures are transmitted without change normally through the film to the surface, and flow in the film behaves in the manner more commonly observed in pipe flow, in that it may be laminar or turbulent depending on the Reynolds number. In this case the characteristic length in the Reynolds number is measured on the surface in the direction of flow from a point of origin.

The boundary layer conditions developed when a thin, flat plate is immersed in a deep, uniform stream of air are fundamental to the case of drying. Figure 1 illustrates the growth of the boundary layer film as current theory depicts it. The leading edge is the point of origin and the Reynolds number increases with distance along the plate to the critical point. The value of the critical Reynolds number is between 80,000 and 500,000 depending on plate roughness and uniformity of the main stream. In the first region the flow is laminar, and the film thickness increases parabolically. Beyond the critical point the flow is turbulent.

The nature of the turbulent film is worth noting, as the physical condition is not completely true to its nomenclature. If the entire film was actually turbulent, the portion of the film in contact with the surface would be in motion, and the velocity gradient normal to the surface would be infinite. Therefore,

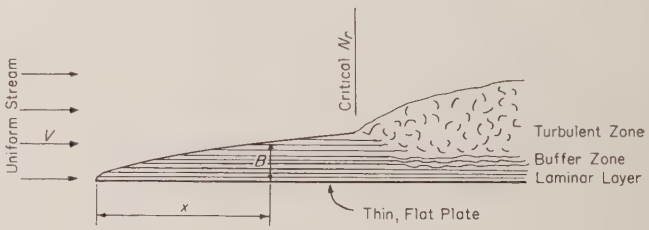

Fig. 1. Boundary layer on flat plate immersed in deep fluid stream

the viscous forces acting on the surface would also be infinite. As this action obviously does not occur, it is manifest that a laminar underlayer exists as part of the so-called turbulent film. Thus, present day theory recognizes the turbulent boundary layer as consisting of three distinct portions: a laminar underlayer, a transition or buffer zone, and the turbulent outer layer.

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The conductance of both heat and mass between a body of surrounding air and a surface are directly dependent upon boundary layer conditions. Since they are affected approximately in the same proportion, (*2*) the former will henceforth be used for simplification. In a laminar film, heat transfer takes place very slowly by conduction. Because air is a relatively poor conductor, thermal gradients are very large, and thus the laminar film might be considered an insulator rather than a conductor.

In a turbulent zone particles of fluid do not move in an orderly fashion as in laminar flow but in eddies from one place to another. Heat is transferred rapidly by convection, and thermal gradients are low. In the more common case of drying with air, the Reynolds number is very high, and a turbulent boundary layer prevails. The familiar Colburn relation is recommended when Reynolds number exceeds 500,000 (*3*).

$$\frac{h}{C_p V \rho} N_p^{2/3} = 0.036 \left(\frac{\mu}{LV\rho}\right)^{0.2} = \frac{0.036}{Nr^{0.2}} \qquad (1)$$

This formula is quite frequently found in its simplified form for air.

$$h_m = 0.0128 G^{0.8} \qquad (2)$$

The theoretical formulas for the boundary layer thickness and the mean heat transfer coefficient for the laminar type boundary layer were developed by Pohlhausen (*4*). With reference to Fig. 1, the thickness is expressed by:

$$\frac{B}{x} = 5.83 \left(\frac{\mu}{xV\rho}\right)^{1/2} \qquad (3)$$

The local heat transfer coefficient is given by:

$$\frac{h_x}{C_p V \rho} N_p^{2/3} = \frac{1}{3} \left(\frac{\mu}{xV\rho}\right)^{1/2} \qquad (4)$$

and the mean coefficient by:

$$\frac{h_m}{C_p V \rho} N_p^{2/3} = \frac{2}{3} \left(\frac{\mu}{LV\rho}\right)^{1/2} = \frac{2}{3} \frac{1}{Nr^{1/2}} \qquad (5)$$

A comparison of equations (3) and (4) shows that thickness and heat transfer contain the length characteristic, x, to the same degree but are inverse functions. In this case, therefore, the thickness of the laminar layer is a good measure of resistance to heat transfer.

THEORY OF THE DRIER

The conventional air drier is comprised of some means to supply air to the surface at a high velocity parallel to the surface. In many cases the air is initially supplied in a direction normal to or at some angle to the surface as a means of obtaining high velocity parallel to the surface. The advantage gained by this procedure is obvious. Since the conventional drier invariably operates at large Reynolds numbers, equations (1) and (2) apply, and heat transfer may be expected to increase with the 0.8 power of the velocity. The two primary obstacles to further advances in heat transfer and the resulting drying rates by increasing velocity are: (1) operating power costs because fan horsepower increases approximately as the square of velocity; (2) effects on the drying material which may suffer from severe displacement or even disruption from the expenditure of excessive amounts of kinetic energy on the surface.

The Gardner drier seeks to provide higher heat transfer by the incorporation of continuum length in addition to high velocity as a major design factor. As previously pointed out, conventional air driers operate with boundary layers mostly in the turbulent phase. Continuum length in the turbulent phase affects the heat transfer coefficient to such a low degree that it has in practice been ignored. If, however, a drier is designed to operate with a laminar boundary layer, continuum length becomes fully as essential as velocity in developing the heat transfer coefficient. For the purpose of demonstration the Pohlhausen equation may be modified by collecting the quantities which are related only to the internal state of the fluid into a single constant, n, to show

$$h_m = n \left(\frac{V}{L}\right)^{1/2} \qquad (6)$$

The heat transfer coefficient thus varies directly with the square root of velocity and inversely with the

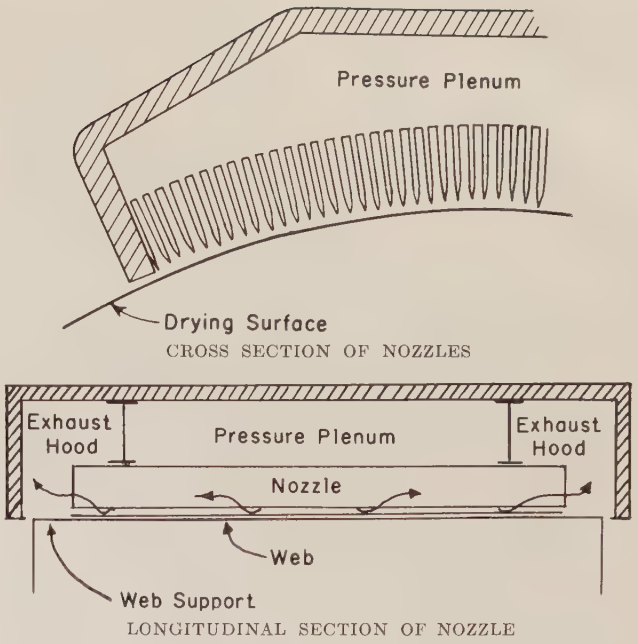

Fig. 2. Nozzle arrangement of Gardner drier

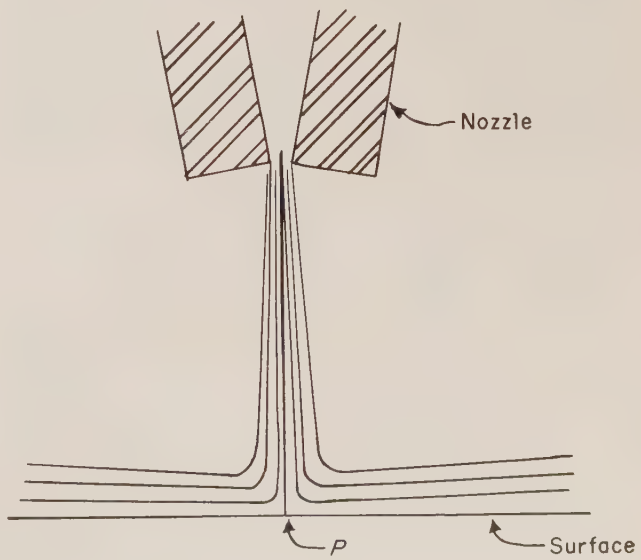

Fig. 3. Single jet with streamlines

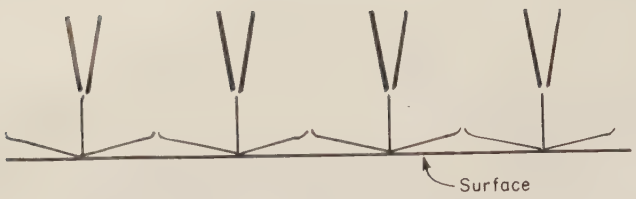

Fig. 4. Stylized effect of series of nozzles on boundary layer

square root of continuum length. The effect may be demonstrated graphically on Fig. 1 where, as x increases, the average thickness of the laminar layer from the origin to x increases. Heat transfer is reduced by a thicker laminar film, and the heat-transfer coefficient is thus an inverse function of continuum length. It follows that every effort should be made to reduce continuum length. The Gardner drier was therefore designed to operate in the laminar region with both high velocity and small continuum length.

The principal component of the Gardner drier is the nozzle arrangement (see Fig. 2). All other details simply serve to enhance or improve the workability of the arrangement. The nozzles are as long as the web is wide and extend from a pressure plenum maintained at a fixed distance from the drying surface. They are spaced at $^3/_4$ or 1 in. centers and mounted within $^1/_8$ to $^1/_2$ in. from the surface depending on the application. The nozzle orifice is less than 0.025 in. Air is supplied to the nozzles at sufficient pressure to produce velocities of 10,000 to 20,000 f.p.m. in the orifices which direct the flow normal to the surface. Since the volume of air from the very narrow orifices is small, the amount of power required is not excessive and the kinetic energy of the jet is low. Furthermore, the small flow permits close spacing of the nozzles without impeding the movement of spent air through the spaces between nozzles to the edge of the web.

The flow of air in jets from the nozzle arrangement produces a pattern of flow on the surface on which boundary layer conditions may be compared to the film on a flat plate investigated by Pohlhausen.

The relative velocity of the air on the surface is many times greater than conventional web speeds, so the effect of web speed is negligible. Furthermore, the nozzles are very long in comparison with their width. Consequently, analysis of the action at any cross section of a jet is indicative of the action at any other cross section, and it may accordingly be analyzed as coplanar flow to a stationary surface. The flow of a single jet on a surface with incident streamlines is

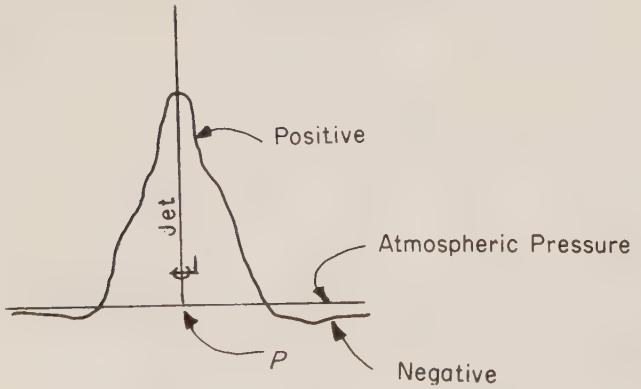

Fig. 5. Pressure contour of jet impinging on a surface

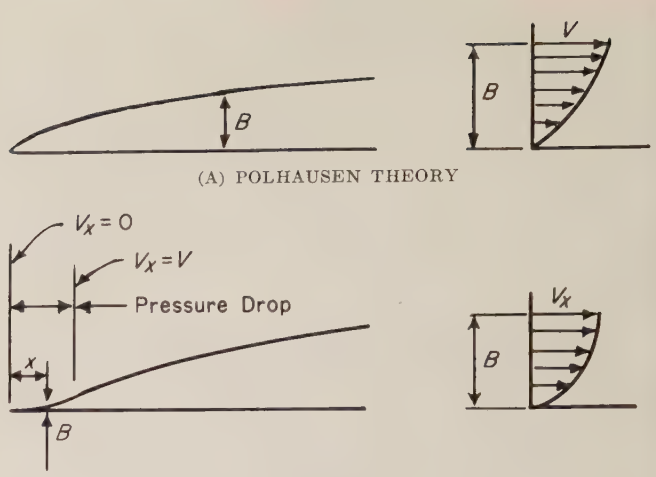

Fig. 6. Transverse velocity distribution

illustrated in Fig. 3. At point P where the center streamline intersects the surface, a pressure is developed. This pressure is defined as the stagnation pressure, and the point itself as the stagnation point. The stagnation pressure exerts itself in all directions from the point, with the result that horizontal flow develops on the surface in both directions from the point. Therefore, the stagnation point is a point source with respect to flow on the surface and is the origin of the boundary layer continuum. The stagnation pressure is rapidly converted to velocity head, and the flow thenceforth approximates the stream specifications for the Pohlhausen theory. Figure 4 shows the greatly stylized effect on the boundary layer of a series of identical jets. The stagnation point is the point of origin, and the boundary layer increases to a point on the surface midway between jets where the flow of adjacent jets collides and leaves the surface

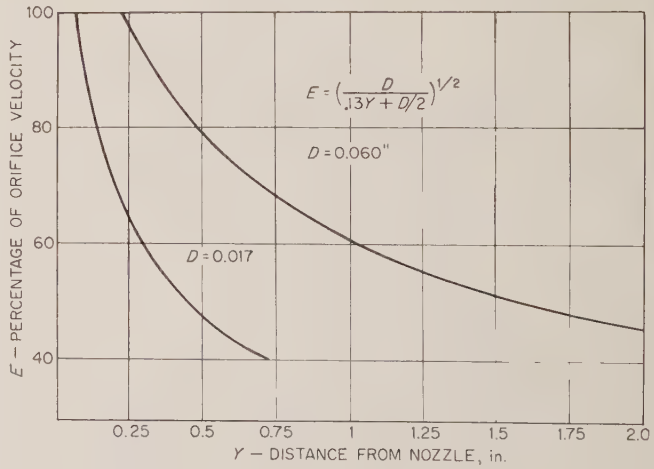

Fig. 7. Variation in impingement velocities with distance from nozzle

The characteristic length of the continuum is observed as being half the distance between jets. If the jets are arranged as previously specified for the Gardner drier, the boundary layer film is always well within the laminar region.

MODIFICATIONS TO THE DRIER THEORY

The direct application of pure theory to practice is

extremely unusual, and this drier is no exception. An experimental investigation of the flow from contemplated nozzle types was made with satisfactory results. Although the tests were quite comprehensive, in the interest of brevity only the pertinent results and conclusions are included here.

The pressure contour on a surface upon which a single jet is impinging at high velocity is shown in Fig. 5. The stagnation point is that corresponding to the peak of the curve. The pressure drops rapidly from the point to a slightly negative value and gradually returns to atmospheric pressure. The velocity parallel to the surface is zero at the stagnation point and increases rapidly along the surface to a maximum value at the lowest point on the pressure curve. Notwithstanding the relatively high velocities involved in this study, the corresponding pressures are yet insignificant in comparison with one atmosphere. Consequently, the gain or loss in drying caused by variation in partial pressures from this source is negligible.

The distance of a nozzle from the surface has several important effects. Starting from the nozzle, the flow undergoes a slight contraction known as the *vena contracta* and subsequently expands at an included angle of about 7° with an accompanying drop in velocity. The curves, Fig. 7, show the variation in velocity with distance from the nozzle for two sizes of nozzle orifice. As related to the drier, this velocity is converted into static pressure upon striking a surface to produce the stagnation pressure. The resulting velocity on and parallel to the surface is a function of the stagnation pressure, and since it is the stream velocity over the boundary layer, it might be called the effective velocity. The width of pressure contour on the surface is directly related to the jet expansion at any given distance. If the nozzle is mounted close to the surface, the stagnation pressure is high, and the width of the pressure contour narrow, which results in a steep pressure gradient within the contour.

No change in the flat-plate analogy can be predicted from the fact that a pressure exists at the point of origin rather than a velocity, for if stagnation pressure was converted instantaneously to velocity, flat-plate flow specifications would be met, but the existence of a pressure gradient makes a significant difference. One tenet of flat plate flow theory is that no pressure drop occurs in the direction of flow. The resultant transverse velocity distribution in a laminar boundary layer is parabolic in form (*5*). Figure 6a illustrates this situation for the classic theory. The problem of an imposed pressure drop in the direction of flow is quite complicated, and no solution was attempted. However, the implied result is shown in Fig. 6b. According to the LaGrange theorem (*6*), a particle moving down the center streamline of a jet impinging on a surface cannot reach the surface in a finite space of time, and the boundary layer at the stagnation point may approach but not equal zero. In the region of steep pressure gradient adjacent to the point, an unusual film condition occurs. Since pressure is transmitted normally through the film without change, all particles in the film are subjected to this pressure gradient in addition to the viscous pull and drag of vertically adjacent particles. As a result, the transverse velocity distribution is deformed to give greater shear stress at the surface with a correspondingly greater velocity gradient near the surface. The curve of the transverse velocity gradient tends to become exponential, for which case, classic theory indicates the laminar boundary layer thickness approaches zero. Therefore, heat transfer in the region directly beneath an impinging jet is likely to be significantly greater than that anticipated by the Pohlhausen equation.

The second point where conditions deviate from pure theory is at the end of the continuum length which has been shown to lie at a point midway between jets on the surface. Here the main streams of air, which should not be confused with the boundary film, from adjacent jets collide and leave the surface. The impact produces pressure, and a secondary region containing a pressure gradient is developed on the surface. Considerable turbulence is also present. Again, while the size of the region is small, its effect will be to augment heat transfer rates as compared to the theory.

A beneficial side effect of the pressure regions may result when webs in a porous condition, as with paper below the critical moisture content, are being dried. The pressure gradients are transmitted to and through the material and may serve to agitate vapor otherwise locked in the pores.

Another characteristic affecting heat transfer is the degree of turbulence in the main streams of air. Although neither the intensity nor the magnitude of turbulence is known, the irregularity of the pressure gradients measured on the surface indicates its presence.

Each of the variations from the prescribed conditions of pure theory appear to augment the heat transfer rates. If the velocity resulting from the conversion of stagnation pressure is taken for the flat plate velocity, the heat transfer coefficient for the standard Gardner drier with nozzles spaced at 1-in. centers is, by Pohlhausen, about 40 B.t.u. per hr.-°F.-sq. ft. Although not formally verified, the practical value of the coefficient appears to be about 55 B.t.u. per hr.-°F.-sq. ft. The factor of modification is then about 1.37.

COMPARISON WITH A TYPICAL DRIER

A mathematical comparison of the Gardner drier, which utilizes the foregoing principles to the practical limit, with a typical drier furnishes a means of estimating the value of this innovation. Because of the great variety of driers presently in use, no drier can truly be called typical, so for the purpose of a comparison, a hypothetical drier with seemingly high drying rates will be chosen. As previously noted, the heat transfer coefficient is the principal concern in determining drying capacity of a drier, and this coefficient depends solely on the boundary layer conditions developed in the drier. Furthermore, neglect of the modification factor as applied to theoretical results should not lead to excessive error. A similar factor applies to all driers, and a variation in excess of twenty per cent would be unusual.

The heat transfer equations may be simplified for the purpose of this comparison. The Colburn relation,

$$\frac{h_m}{C_p V \rho} N_p^{2/3} = 0.36 N_r^{-0.2},$$

becomes

$$a h_m = 0.36 N_r^{-0.2} V, \qquad (7)$$

where a is a constant replacing the quantities describing the internal state of the air. This equation is recommended only for Reynolds numbers in excess of 500,000. The Pohlhausen relation,

$$\frac{h_m}{C_p V \rho} N_p^{2/3} = 0.66 N_r^{-0.5},$$

becomes

$$ah_m = 0.66 N_r^{-0.5} V. \qquad (8)$$

This equation is recommended only for laminar film conditions that occur at Reynolds numbers below 80,000 to 500,000. Where split conditions, both a laminar and a turbulent zone, occur at Reynolds numbers less than 500,000, the heat transfer coefficient lies somewhere between the limits of the Pohlhausen relation with Reynolds number of 80,000 and the Colburn relation with Reynolds number of 500,000.

The standard construction of the Gardner drier is typified by nozzles spaced $^1/_4$ in. from the surface, 1 in. apart, and directed normal to the surface. A velocity of 15,000 f.p.m. is maintained at the nozzle orifice which averages about 0.017 in. wide. The flow amounts to about 210 c.f.m. per sq. ft. of drying surface. According to the nozzle flow tests the effective velocity at the stagnation point is 9600 f.p.m. Continuum length is $^1/_2$ in.

For the typical drier let us choose slotted nozzles mounted 3 in. from the surface, 8 in. apart, directed normal to the surface. A velocity of 10,000 f.p.m. through 0.20-in. nozzles gives a flow of about 205 c.f.m. per sq. ft. if the same orifice coefficient is used. From the nozzle tests the effective velocity at the stagnation point is about 6400 f.p.m. Continuum length is 4 in.

Assuming typical values of density at 0.052 lb. per cu. ft. and absolute viscosity at 0.056 lb. per hr.-ft., the Reynolds number for each of the driers is as follows:

$$\text{Typical:} \quad N_r = \frac{LV\rho}{\mu} = \frac{(4)\ (6400)\ (60)\ (0.052)}{(12)\ (0.056)} = 119{,}000;$$

$$\text{Gardner:} \quad N_r = \frac{LV\rho}{\mu} = \frac{(^1/_2)\ (9600)\ (60)\ 0.052)}{(12)\ (0.056)} = 22{,}300.$$

The Gardner drier is very definitely in the laminar region, but the typical unit is in the critical range, being either entirely laminar or split with both laminar and turbulent zones.

Heat transfer comparisons are made by substituting in equations (7) and (8). The typical drier must be calculated both ways, as its coefficient lies somewhere between that determined for laminar flow and that for turbulent flow.

Typical:

$$ah_m = (0.66)\ (119{,}000)^{-0.5}\ (6400) = 12.2 \text{ (laminar)}$$
$$ah_m < (0.036)\ (119{,}000)^{-0.2}\ (6400) = 22.2 \text{ (turbulent)}$$

Gardner: $ah_m = (0.66)\ (22{,}300)^{-0.5}\ (9600) = 42.5$ (laminar)

All conditions being equal, therefore, the Gardner drier will have a drying capacity on a moist surface two or three times greater than the typical unit. In the case of nonsaturated surface drying the advantage would be less depending on the amount of additional resistance imposed by the surface material.

The destructive effect of the primary air jet on a surface is an important secondary comparison. If the force of the jet is too strong it may throw waves or wrinkles in a web even to the extent that the web ruptures. Surface pressures of the magnitude considered here are not of themselves destructive. The forces resulting from these pressures can be, particularly because the pressures are exerted on very small areas at frequent intervals. The force per nozzle is given by the equation.

$$F = \frac{A\rho V^2}{2g} \qquad (9)$$

The two units may be compared by substitution in the equation to give:

$$\text{Typical:} \quad F = \frac{(0.2)\ (0.052)\ (10{,}000)^2}{(12)\ (64.4)\ (60)^2} = 0.373 \text{ lb.};$$

$$\text{Gardner:} \quad F = \frac{(0.017)\ (0.052)\ (15{,}000)^2}{(12)\ (64.4)\ (60)^2} = 0.072 \text{ lb.}$$

These quantities represent the force per foot of nozzle length. The jet of the typical drier has about five times the strength of the Gardner Drier jet. The shear stress on the surface is important as it may in various applications raise fiber from the web or cause coatings and inks to run. Although no reasonable estimate of these shear stresses can be made for this comparison, a generalization of the boundary layer theory implies that they are considerably less than under turbulent films. Shear stress is proportional to velocity gradient, which tends to approach infinity at the surface with turbulent flow.

SUMMARY

The pattern of air flow developed on a drying surfac by the Gardner drier produces a laminar boundary layer film which is highly analogous to the Pohlhausen theory for a thin, flat plate immersed in a deep, uniform stream of fluid. According to the theory, a laminar fluid film is formed on the surface of the plate. This film thickness increases parabolically from the leading edge to a point where the Reynolds number becomes critical. By operating at low Reynolds number on a drying surface, the Gardner drier utilizes the film condition nearest the leading edge where the film thickness is small and the related heat and mass transfer coefficients are high. This is accomplished by an arrangement of closely spaced nozzles supported very near the drying surface. The jet velocity from the small nozzle orifices is high but not harmful to the surface. The resulting flow on the surface approximates the theoretical flat plate flow specifications. The deviations from the theoretical flow serve to augment heat transfer. The theoretical heat transfer coefficient is about 40 B.t.u. per hr.-°F.-sq. ft., and the actual is believed to be about 55 B.t.u. per hr.-°F.-sq. ft.

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ASSOCIATION NEWS AND EVENTS

National Conferences

1960

Eleventh Testing Conference, Sept. 27–29, 1960, Pantlind Hotel, Grand Rapids, Mich.

Fifth Deinking Conference, Oct. 5–7, 1960, Conway Hotel, Appleton, Wis.

Tenth Corrugated Containers Conference, Oct. 10–13, 1960, Royal York Hotel, Toronto, Ont.

Fifteenth Plastic Plastics-Paper Conference, Oct. 17–19, 1960, Syracuse Hotel, Syracuse, N. Y.

Fifteenth Engineering Conference, Oct. 24–28, 1960, Robert Meyer Hotel, Jacksonville, Fla.

Fundamental Research Conference, Nov. 3–5, 1960, Northampton Hotel, Northampton, Mass.

1961

46th Annual Meeting, Feb. 19–23, 1961, Commodore Hotel, New York, N. Y.

Twelfth Coating Conference, May 22–24, 1961, Statler-Hilton Hotel, Buffalo, N. Y.

Twelfth Testing Conference, Aug. 15–18, 1961, Queen Elizabeth Hotel, Montreal, Que.

Eleventh Corrugated Containers Conference, Sept. 11–13, 1961, St. Francis Hotel, San Francisco, Calif.

Fourth Mechanical Pulping Conference, Sept. 19–21, 1961, Edgewater Beach Hotel, Chicago, Ill.

Symposium on Formation and Structure of Paper, Sept. 25–29, 1961, B.P.B.M.A., Oxford, England.

Sixteenth Plastics-Paper Conference, Oct. 9–11, 1961, French Lick Sheraton Hotel, French Lick, Ind.

Sixteenth Engineering Conference, Oct. 15–19, 1961, Shoreham Hotel, Washington, D. C.

Fifteenth Alkaline Pulping Conference, Nov. 1–3, 1961, Rice Hotel, Houston, Tex.

1962

47th Annual Meeting, Feb. 18–22, 1962, Commodore Hotel, New York, N. Y.

Thirteenth Coating Conference, May 14–16, 1962, Netherland-Hilton Hotel, Cincinnati, Ohio.

Thirteenth Testing Conference, Sept. 18–20, 1962, Benjamin Franklin Hotel, Philadelphia, Pa.

Seventeenth Engineering Conference, Oct. 14–19, 1962, Queen Elizabeth Hotel, Montreal, Que.

Twelfth Corrugated Containers Conference, Oct. 23–26, 1962, Statler-Hilton Hotel, Boston, Mass.

Sixteenth Alkaline Pulping Conference, 1962, Savannah, Ga.

1963

Fourteenth Coating Conference, May 19–22, 1963, French Lick Sheraton Hotel, French Lick, Ind.

Thirteenth Corrugated Containers Conference, Oct. 22–25, 1963, Statler-Hilton Hotel, Detroit, Mich.

Eighteenth Engineering Conference, 1963, Chicago, Ill.

Ohio Section Program for October

Three concurrent seminars on continuous pulping, stock preparation, and advancements in waste paper utilization will highlight the October 13th meeting of the Ohio Section of TAPPI in the Hotel Manchester, Middletown, Ohio. The one-day program also includes a tour of the new Black-Clawson Research Center in Middletown, where pilot operations of new stock preparation and cold soda pulping equipment will be demonstrated.

Participating as panelists in the seminars are prominent production and research experts from the national industry. The meeting is under the direction of Ohio Section Chairman Charles S. Sweitzer (Diamond National Corp.) and Program Chairman Frank Cessna (Sorg Paper Co.).

The events of the meeting are tentatively scheduled as follows:

10:00 a.m.–12:00 noon—Meeting registration.

12:00 noon–1:30 p.m.—Luncheon for all, sponsored by The Black-Clawson Co.

1:30–3:30 p.m.—Seminar Sessions

Session A—Continuous Pulping Seminar

Subjects: "NSSC, Cold Soda, Kraft—Why Continuous Processing?"

Moderator: John N. McGovern, Parsons & Whittemore, Inc.

Panelists: Robert Green, Champion Paper & Fibre Co.; G. H. Chidester, U. S. Forest Products Laboratory; Robert Fuller, Gulf States Paper Corp.

Session B—Stock Preparation Seminar

Subjects: "Equipment Advancements—Vokes Rotor for Hydrapulpers, Hardwood Disk Refining, Improved Broke Handling"

Moderator: E. M. Root, The Black-Clawson Co.

Panelists: Donald J. Monk, Fibreboard Paper Products Corp.; Douglas G. Sutherland, The Black-Clawson Co.; Bernard H. Bamer, Stone Container Corp.

Session C—Wastepaper Utilization Seminar

Subjects: "Wastepaper versus Virgin Hardwood Pulp; Improved Asphalt Dispersion; Approaches to Better Filler and Liner Systems"

Moderator: A. T. Luey, Box Board Research & Development Assn.

Panelists: Robert E. Brown, Alton Box Board Co.; W. Francis Bathon, Elk Paper Manufacturing Co.; C. D. Coffman, Chesapeake Paperboard Co.

3:30–5:30—Open House at Black-Clawson Research Center, including demonstrations of Vokes Rotor development and Pandia Cold Soda Pulping System.

6:00–7:00—Hospitality Hour, Hotel Manchester, Black-Clawson, Host.

7:00—Ohio Section TAPPI Banquet, Hotel Manchester Ball Room

8:00—Banquet Speaker—Edward J. Jones, The Institute of Paper Chemistry.

Advanced reservations and hotel accommodations should be made through Edward Norris, Champion Paper and Fibre Co., Hamilton, Ohio.

Technical Association in Mexico

A large delegation of company executives and technical men greeted R G. Macdonald, Treasurer and Editorial Director of TAPPI, in Mexico City on June 20, 1960. In addition to attending the meeting of the American Institute of Chemical Engineers, Mr. Macdonald had the opportunity

Mario Jaimes de la Vega and George Soyka, consultants; John Rudolf, Parsons & Whittemore de Mexico; and A. M. Leth, Celulosa de Chihuahua

to talk to officials of most of the pulp and paper companies and converters in Mexico. There are about 35 important companies in Mexico. John Rudolf of Parsons & Whittemore de Mexico was host at this reception.

Visits were made to the mills of such companies as Cia. de las Fab. de Papel San Rafael, Loreta y Pena Pobre, Cia. Ind. de San Cristobal, Kraft S. A., Cajos y Envases Corregados, Negociacion Papelera Mexicana and the Laboratories Nacional de Fomento Industrial.

At the reception on June 20, Mr. Macdonald discussed with a group of about 60 paper company representatives the considerable benefits of establishing and maintaining a technical association. An exceptional opportunity exists to have an association concerned with the Spanish language. Much of the literature, articles, books, standard testing methods, and data sheets are printed in other languages and could be translated into Spanish and thereby made available to the Spanish speaking world.

A smaller meeting was held on June 2 as guests of Bill Velez, Manager of Cameron Machine Co. International, and on Thursday, June 23, an official meeting of the Camara Nacional de las Industrias del Papel was held to act on suggestions made by Mr. Macdonald. At this meeting a steering committee was appointed to meet on July 8 to implement the organization of a technical association of the paper industry in Mexico. This committee consisted of A. M. Leth, Celulosa de Chihuahua; Carlos Garcia Robles, Consultant; Sergio Vadillo, San Rafael y Anexas; Dante Sandro Cusi, Cia. Ind. de San Cristobal; and Lic. Antonio Hinojose, Empaques de Carton Titan S. A.

During the week the following representatives of the industry participated in the meetings that gave consideration to the formation of a technical association:

Adalberto Tirado, Pena Pobre
Henry Dabdoub, Kraft, Cajos y Empaques
Abraham Dabdoub, Kraft, Cajos y Empaques
Claudio Gonzales, Kimberly-Clark

Fernando de la Macorra, San Rafael y Anexas and R. G. Macdonald, TAPPI

On a recent goodwill tour to the Mexican pulp and paper industry Dr. R. G. Macdonald, Treasurer of the Technical Association of the Pulp & Paper Industry, discussed the problems of establishing technical information exchange within the Mexican industry with the heads of several pulp and paper companies. In conversation with Dr. Macdonald (left) are (l. to r.) Oliver Scott, Dr. Roy Davis, Ing. C. Alvarez, and Ing. M. Jaimes de la Vega

Aurable Carriles, Cartonajes Estrella
Stan Nungas, Cartonajes Estrella
Felix Ortiz, Cartonera Moderna
Mario de la Torre, Cerro Gordo
Lorenzo Arcelus, Iruna
Guillermo Farell, Iruna
Rafael Vallina, Celulosa de Chihuahua
A. M. Leth, Celulosa de Chihuahua
E. Olmeda, Negociacion Papelera Mexicana
Roy Davis, Cia. Ind. de San Cristobal
Hank Godshall, Jr., Ind. de San Cristobal
S. Steiner, Ind. de San Cristobal
Fernando de la Macorra, San Rafael y Anexas
Jesus Escalante, San Rafael y Anexas
Herbert Byrd, Sonoco de Mexico
Richard Mollinson, Sonoco de Mexico
Hans Bettschen, United, San Pablo
Martin Keller, United, San Pablo
Mario Jaimes de la Vega, Consultant
Carlos Ziegler, Celanese
Paul Cannon, Celanese
Carlos Garcia Robles, Consultant
Joel Ferry, Conos y Tubos
Arturo Rodriguez Ullva, Consultant
Arturo Ceniceros, Consultant
P. Garcia Verduzco, Atenquiqe
Oliver Scott, Combustion Engineering Inc.
Guillermo Nunez, Santa Clara
Ake P. G. von Schussler, Banker
Frederick Kirseborn, Economist
Constantino Alvarez, University of Mexico
Jose Antonio Hinojosa, Camara Nacional de las Industria del Papel
Luis Gomez Dominquez, Camara Nacional de las Industria del Papel
Paul Flores, U. S. Embassy
Thomas Carter, A.E.I.
David Woodfall, English Electric Co.
Jaime Osollo Alvarez, El Pilar
Robert Lewis, Los Rejes
George Soyka, Consultant
John Rudolf, Parsons & Whittemore de Mexico
Guillermo Velez, Cameron Machine Co.
Manuel del Castillo, Import y Export Mexicanas
Artabio Lara, Papelera "El Fenix"
Gustavo Gottfried, Reliance Elec. & Eng. Co.
Mario Gottfried, Reliance Elec. & Eng. Co.
Mitchell Thom, Empaques de Carton United
David Riercon, Papel Santa Clara
Ignacio de la Garza, Fabricas de San Rafael
Sergio Vadillo, Fabricas de San Rafael
Jose Garcia Gutierrez, Fabricas de San Rafael
Daniel Rodriquez, Fabricas de San Rafael
Francisco J. Olavarrieta, Fabricas de San Rafael
Eunque Pareja, Fabricas de San Rafael
Ricardo Mejenes, Fabricas de San Rafael
Samuel D. Albores, Economista de la Camara
Carlos Miranda, Carton y Papel de Mexico

From the Paper Research Laboratory of The New Jersey Zinc Company
ONE of a Series of Test Procedures on Horse Head Titanium Dioxide

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A new method of evaluating abrasiveness of paper fillers employs a drill press in which a felt pad immersed in filter slurry is rotated under pressure against a brass disk. The amount of metal abraded is determined by weighing the disk before and after the test.

In the broad range of studies in the current paper research program at New Jersey Zinc, evaluation of the abrasive effect of various pigments occupies a considerable portion of the time of the laboratory's investigators. And well it might, since abrasiveness is a topic of extreme importance to paper maker and paper user alike.

The development of new and more practical paper pigment testing techniques, such as the one shown here, is providing new knowledge on the performance of titanium dioxides in high grade paper products. Too, it is serving to keep HORSE HEAD titanium dioxides in the forefront of top quality, dependable paper pigments.

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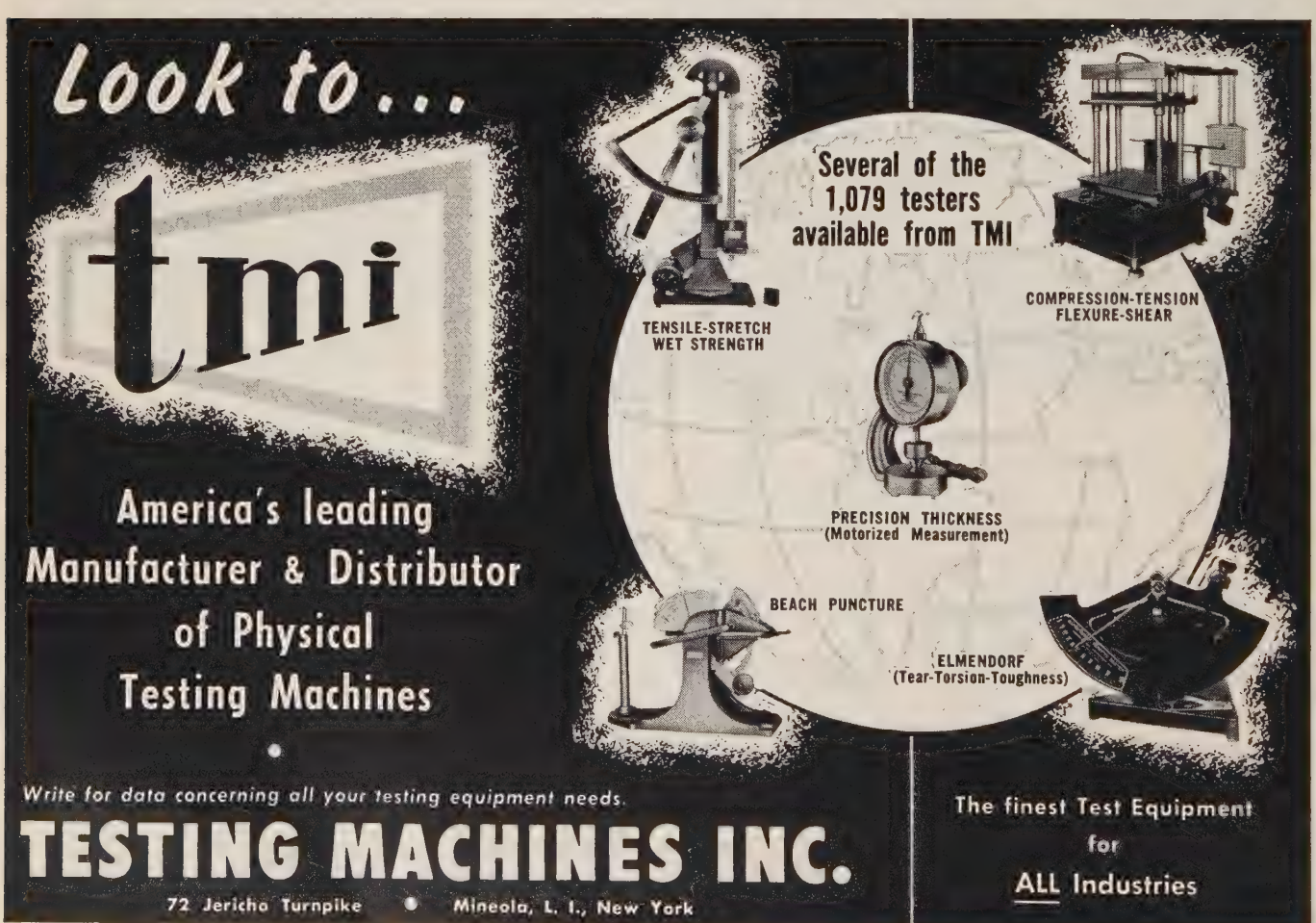
Castillo De San Marcos National Monument. The Castillo was started in 1672 and its 16-foot-thick walls are raised of coquina (pronounced ko-KEE-na), the shellrock quarried from pits across the Bay on Anastasia Island. This fort, remarkably well preserved, is an excellent example of Spanish Renaissance fortification

Oldest Wooden Schoolhouse, 14 St. George St. This is the only remaining 18th Century wooden building in St. Augustine. Erected during the middle 1700's, with hand-hewn cedar clapboards, it later became a school

Fifteenth Engineering Conference

At the Annual Engineering Conference banquet on Wednesday evening, October 26, 1960, W. H. Zinn, Combustion Engineering, Inc., Windsor, Conn., will be the featured speaker. Dr. Zinn's topic will be "Nuclear Energy for Industrial Power."

Dr. Zinn was a corecipient of the "1960 Atoms for Peace Award" and is a member of the President's Scientific Advisory Committee. He was the first president of the American Nuclear Society, a membership he retains as well as membership in the National Academy of Sciences, the American Physical Society, and the American Association for the Advancement of Science.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City Gate. The stone pillars are the only visible remains of the 18th Century town wall. During the first half of the 1700's, St. Augustine was the target for numerous British and Indian attacks. When these invaders left, they destroyed many buildings. Early in the 1700's the Spanish built a great earth wall around St. Augustine and planted this wall with Spanish Bayonet (yucca gloriosa), the sharp points of which were as effective as barbed wire. Thenceforth no invader ever forced his way into the city. The stone pillars were built about 1804, replacing earlier wooden gateways. This was the main land entrance to the town—the only gate in a nine-foot palisaded earthwork that ran west from the Fort to fence the St. Augustine peninsula completely across. At the gateway a bridge spanned the moat, and a draw span hauled up between the pillars. Vestiges of the moat remain, and the base of the palisade is still intact under ground

Dr. Zinn received his Bachelor's and Master's degrees from Queens University, Kingston, Ont., and his Doctorate from Columbia University, New York. He also received an honorary Doctorate from Queens University.

Dr. Zinn is president of General Nuclear Engineering Corp., a subsidiary of Combustion Engineering, Inc. He is also vice-president of the latter company and is responsible for its nuclear power activities.

In addition to a diversified and comprehensive technical program of 18 technical sessions and several panels on all major aspects of engineering applications and progress in the pulp and paper industry, the Fifteenth Engineering Conference, to be held Oct. 24–28, 1960, at the Robert Meyer Hotel, Jacksonville, Fla., now announces a special program for the ladies attending the meeting.

W. H. Zinn, Combustion Engineering, Inc.

Mrs. L. C. Crowder, chairman of the Ladies' Program Committee with the able assistance of Mesdames J. C. Peebles, Jr., W. B. Hobbs, H. R. Emery, F. A. Adams, J. E. Baber, R. F. Sorenson, and F. W. Elser has arranged a most interesting program as follows:

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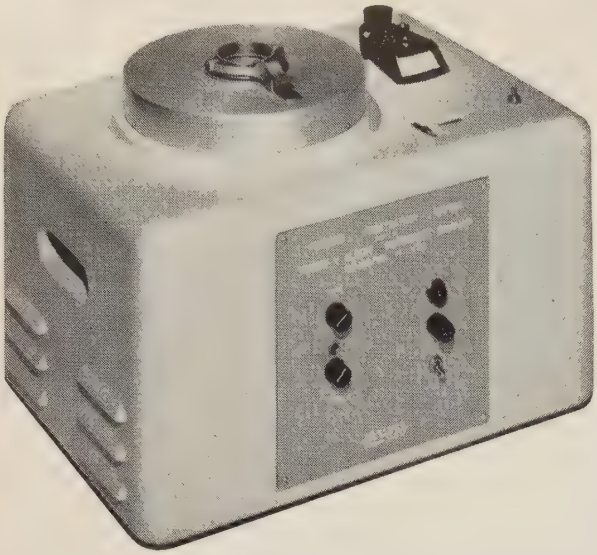

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Photoelectric cells quickly detect slight changes in the light reflected from sample.

Small imperfections in sample have little effect on reading.

Automatically registers time cycle when test is completed.

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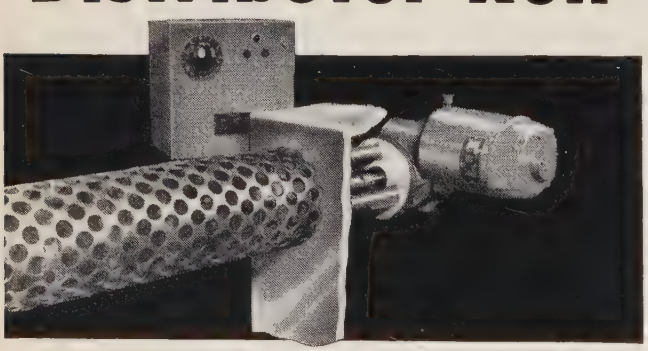
The Oldest House, 14 St. Francis Street, at the south end of the seawall on the street of the Franciscans, on a site occupied since the early 1600's. Owned by the St. Augustine Historical Society and exhibited as a house museum accurately depicting life in early colonial St. Augustine. The present house with its native coquina walls and hand-hewn beams was constructed about 1703. In the patio surrounding the old well is a colonial garden of plants, trees and shrubs such as were grown in St. Augustine during Spanish colonial period. Open daily 9 A.M. to 6 P.M. Adm. Charged. St. Augustine Historical Society Library, adjacent to the Oldest House; contains specialized collection containing 7500 volumes in addition to microfilm, photostats, maps, photographs, etc. for the use of persons interested in colonial Spanish history

SANDY HILL
Distributor Roll



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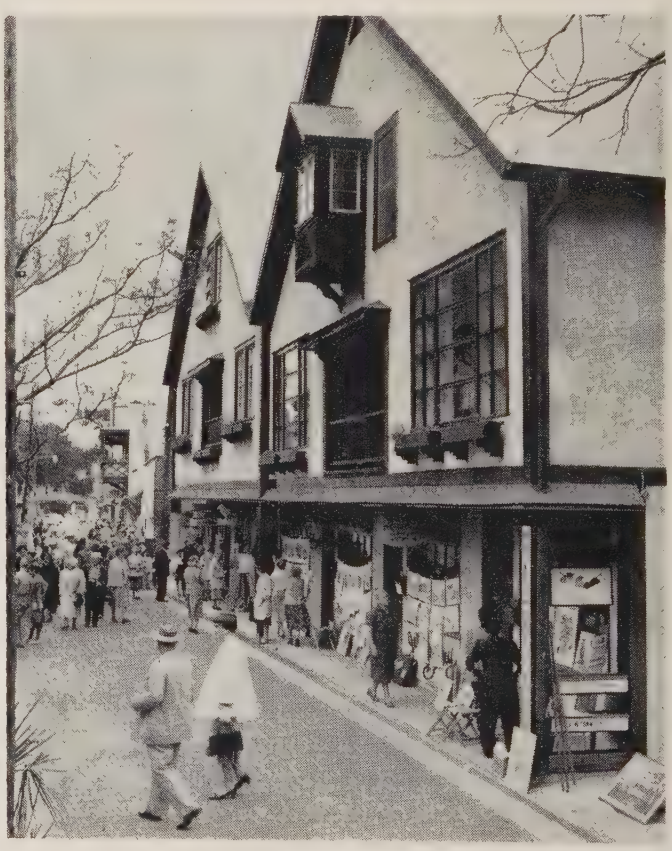


Aviles Street, leading south from the Plaza, is an unusually picturesque street, named after the Spanish birthplace of Menendez, the founder of St. Augustine. Like many other streets in the town, this one ends in a cross street, instead of running straight through for many blocks. Short streets ending in the middle of a block were easier to defend; the enemy could not race through the town on a single thoroughfare

St. Regis Paper Co., Jacksonville, Fla.

SUNDAY, OCTOBER 23

Ladies' Hospitality Room open during registration periods (Executive Suite, Room 502)

MONDAY, OCTOBER 24

10:00–11:30 a.m.
Ladies' Get-Together (Executive Suite, Room 502). Coffee will be served

1:00 p.m.
Film Preview of St. Regis mill tour (George Washington Hotel Ball Room)

1:45 p.m.
Buses leave George Washington Hotel for tour of St. Regis' Jacksonville mill, followed by a quick tour of the city. (Lowheeled shoes are suggested)

5:00 p.m.
Return to hotel.

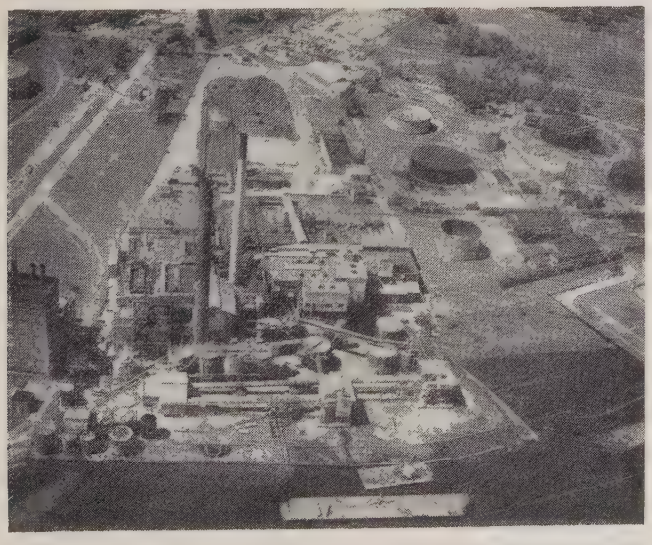
TUESDAY, OCTOBER 25

10:00 a.m.
Buses leave Robert Meyer Hotel for all-day tour of St. Augustine, Fla. (This will include tours of Castillo de San Marco, America's oldest school house, sightseeing tours of artists' colony, and quaint shops of the city.) Lunch will be served at the Old Spanish Treasury

4:00 p.m.
Depart for Jacksonville

WEDNESDAY, OCTOBER 26

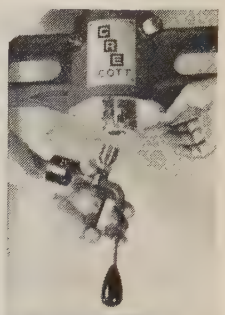
12:00 noon
Luncheon and millinery fashion review



Owens Illinois Glass Co., Mill Division, Jacksonville, Fla.

You can change a complete set of clamps on a Scott Tester...in a matter of seconds!

Here's how:

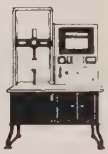


2 sec.
Locking pin out — top clamp off.

4 sec.
New clamp in position — pin replaced.

6 sec.
Locking pin out — bottom clamp off.

8 sec.
New clamp on — pin replaced — locking collar tightened. That's all — start testing!



With Scott's new quick-change clamp assembly, you speed up your test operations and get more tests per day. This is another reason why Scott Model CRE Constant-Rate-of-Extension Tester makes good sense and good savings in the laboratory or in production.

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Scott Clamps and Holding Fixtures are equally useful and time-saving on other Scott Tensile Testers. Ask for details.

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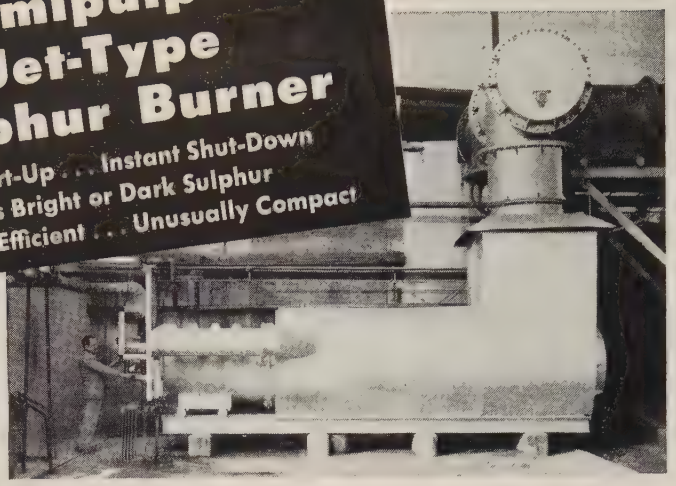
- Fast Start-Up . . . Instant Shut-Down
- Handles Bright or Dark Sulphur
- Highly Efficient . . . Unusually Compact



30-ton installation, Rayonier Canada Limited, Port Alice, B. C.

In the Chemipulp-KC Burner, molten sulphur is sprayed into the burner as a fine mist; heated secondary air is then introduced in several stages, resulting in clean, efficient burning. The burner quickly reaches its operating temperature of about 2400°F., minimizing production of SO_3. Operates efficiently at all SO_2 concentrations between 12% and 18½%. At 2100°F, bitumen in dark sulphur is completely burned.

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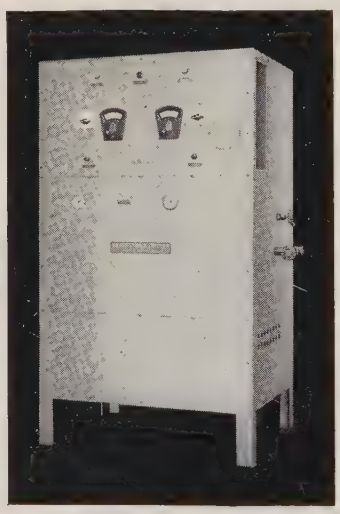

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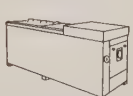

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6:30 p.m. to 7:30 p. m.
Convention hospitality hour for husbands and wives (George Washington Auditorium)

7:30 p.m.
Convention banquet and dance for husbands and wives

THURSDAY, OCTOBER 27

All day. Ladies' Hospitality Room (Executive Suite 502) will be open for cards and conversation

While the ladies are touring St. Augustine, the men attending the conference may wish to visit the St. Regis Paper Co., or Owens-Illinois, each in Jacksonville on Tuesday afternoon, October 25.

ST. REGIS PAPER CO.

The Jacksonville mill originally built in 1952, comprised one kraft paper machine with the daily capacity of 350 tons, employing 400 personnel. Number 1 machine is the fastest sectional kraft paper machine in the world. In 1957 no. 2 paper machine, nicknamed "The Seminole Chief" was installed and has a daily capacity of 1000 tons. This is the largest kraft paper machine of its type in the world. Personnel of the mill totals 850.

A walking tour of the mill will be arranged and in addition a 30-min. color film which depicts the operations of the mill will be shown at the hotel.

OWENS-ILLINOIS GLASS CO., MILL DIVISION

The Owens-Illinois Forest Products Group, the second largest operating group of the company, consists of divisions and subsidiaries concerned primarily with the manufacture and sale of containerboard, corrugated and solid fiber shipping boxes, and multiwall bags. The Mill Division, an integral part of the group, operates five paper mills and approximately 1,124,000 acres of owned or leased woodlands.

The Mill Division has mills at Jacksonville, Fla., Valdosta, Ga., Tomahawk, Wis., Big Island, Va., and Jaite, Ohio.

The mill began operation during April of 1938, producing kraft linerboard at a rate of 150 tons per day. Present production averages more than 500 tons daily. Five hundred and fifty people keep the mill operating 24 hr. a day, 7 days a week.

One fourdrinier-type paper machine continuously produces a sheet of paper 212 in. wide at a speed of about 1100 f.p.m.

A unique feature of the Jacksonville mill is the fact that, in addition to pulp wood produced locally, wood is imported from the Bahama Islands where O-I has cutting rights on 300,000 acres of woodlands.

Hotel accommodation requests should be addressed to "TAPPI 15th Engineering Conference, Robert Meyer Hotel, Jacksonville, Fla.," stating date and time of both arrival and departure.

Fifteenth Plastics-Paper Conference

The Fifteenth Plastics-Paper Conference, scheduled to be held Oct. 16–19, 1960, at the Syracuse Hotel in Syracuse, N. Y., is sponsored by the Converting and Consuming Division, J. C. Pullman, American Cyanamid, New York, N. Y., chairman. This division includes the Plastics, Plastic Laminates, and Wet-Strength and Interfiber Bonding Committees of the Association.

The general conference chairman is V. T. Stannett, College of Forestry, Syracuse, N. Y.; R. W. Loheed, Chas. T. Main, Inc., Boston, Mass., is technical program chairman; and C. G. Morse, Sealright-Oswego Falls Corp., Fulton, N. Y., is local arrangements chairman.

Mr. Loheed has arranged further details of the technical program and while some final arrangements still need to be made, the program for the conference will be as given below.

On Monday, October 17, Donald H. Davenport, Deputy Commissioner of the New York State Department of Commerce will be the featured speaker at the banquet in the evening. His topic will be "The State and Industries' Role in Research."

There are two tours arranged for Tuesday afternoon, Oct. 18, 1960. One tour will be a visit to the College of Forestry, V. T. Stannett, host, and the second will be a visit to Dilts Div., The Black-Clawson Co., Fulton, N. Y., R. W. Phelps, host.

PROGRAM

SUNDAY, OCT. 16, 1960

4:00–10:00 p.m. Registration (Assembly Foyer—10th Floor)

MONDAY, OCT. 17, 1960

8:00 a.m. Registration (Assembly Foyer—10th Floor)

9:00 a.m. Opening Remarks: E. C. JAHN, Associate Dean of College of Forestry Syracuse University, Syracuse, N. Y.

9:15 a.m. Wet Strength & Interfiber Bonding Session

K. W. BRITT, Scott Paper Co., Chester, Pa., *chairman*

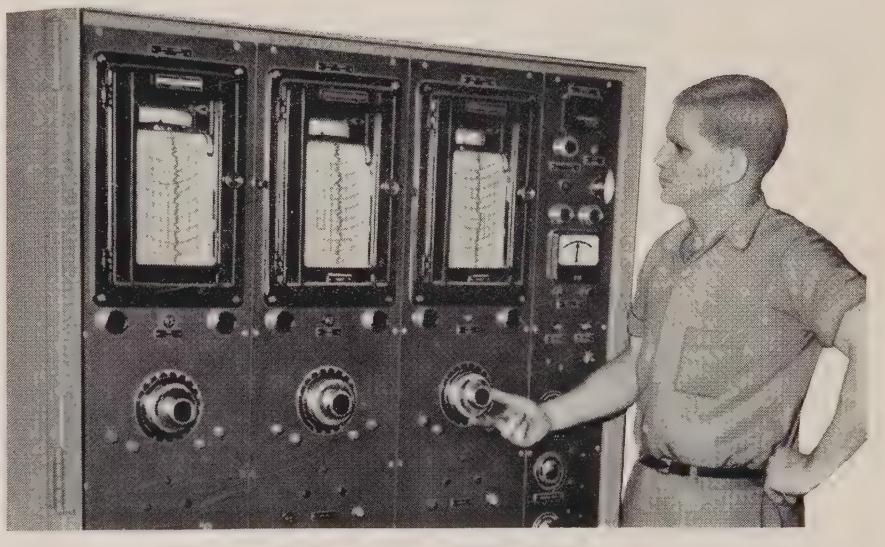
1. "The Mechanism of Retention of Wet-Strength Resins. III. The Rate Controlling Step," by J. J. Becher, The Institute of Paper Chemistry, Appleton, Wis.
2. "Cure of Wet-Strength Resins," by V. T. Stannett, College of Forestry, Syracuse University, Syracuse, N. Y.
3. "Potential Military Application of Disposable Clothing Progress Report," by G. R. Thomas, Quartermaster Research and Development Command, Natick, Mass.
4. "Polyvinyl Acetate Latices as Wet-End Additives," by R. S. Drake, B. F. Goodrich Co., Avon Lake, Ohio.
5. "Some New Developments in Synthetic Fiber Papers," by R. A. A. Hentschel, Textile Fibres Dept., E. I. du Pont de Nemours & Co., Wilmington, Del.

2:00 p.m. Plastics Committee Session

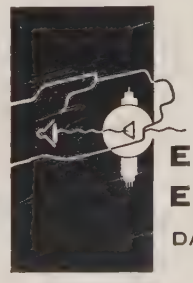
W. N. STICKEL, Texon, Inc., S. Hadley Falls, Mass., *chairman*

6. "The Delamination Strength of Latex-Treated Papers," by K. Sarkanen, V. T. Stannett, and T. C. Lee, College of Forestry, Syracuse, N. Y.
7. "Grafting Monomers onto Cellulose and Cellulosic

Automatic HURLETRON Caliper and Weight Control... assures a New Standard of Quality for Paperboard-Makers



Under the watchful eyes of Hurletron Caliper and Weight Control, fluctuations at the wet end of the paperboard machine are automatically held to *plus or minus one point.* This control system continuously inspects the paper web to detect out-of-caliper conditions or variations in basis weight, and it instantly and *automatically* corrects for irregularities as soon as a trend has been established. Hurletron Control also provides a continuous, permanent record of finished caliper at the dry end after the calender stack. In mills across the nation, the Hurletron is producing new economies... new uniformity... new standards of quality in board production! Write for details *today.*



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Fibers," by J. J. Hermans and V. T. Stannett, College of Forestry, Syracuse, N. Y.

8. "Paper and Plastic Requirements for the Expresso Carton and Machine Operation," by I. Lester, Mead Packaging Corp., Atlanta, Ga.
9. "What Worth Packaging Education?" by H. G. Walter, Packaging Foundation, Inc., Chicago, Ill.

6:00 p.m. Reception (Dutch Treat), East Room
7:00 p.m. Banquet—Ballroom

Speaker: D. DAVENPORT, Deputy Commissioner of Commerce, New York State. "The State and Industries' Role in Research"

TUESDAY, OCT. 18, 1960

8:00 a.m. Registration (Assembly Foyer, 10th Floor)
9:00 a.m. Plastic Coating Session—Plastics in the Paperboard Industry

G. L. BOOTH, Dilts Machine Works, Fulton, N. Y., *chairman*

10. "Surface Treatment of Polyethylene Coated Paper and Paperboard," by S. Leeds, Union Carbide Plastic Co., Boundbrook, N. J.
11. "A Look at the Future in the Packaging Industry," by C. G. Morse, Sealright Co., Fulton, N. Y.
12. "Reclamation of Plastic Coated Board," by J. Dow, Shartle Division, The Black-Clawson Co., Middletown, Ohio.
13. "Methods of Making and Applying Plastic Films" (film 25 min. long), presented by C. J. Wachter, G. C. Lane, and R. A. Nunn, Waldron-Hartig Division of Midland Ross Corp., New Brunswick, N. J.

1:00 p.m. Transportation to Fulton
2:00 p.m.-4:00 p.m. Committee Meetings

(a) Project no. 803—Catalog of Plastics-Paper Combinations—Subcommittee
(b) Extrusion Coating Subcommittee
(c) Plastics Committee
(d) Wet Strength and Interfiber Bonding Plastics Laminates
(e) Synthetic Fibers Committee

6:00 p.m. 16th Paper-Plastics Conference Committee Reception
7:00 p.m. Division Officers' Dinner

WEDNESDAY, OCT. 19, 1960

8:00 a.m. Registration
9:00 a.m. Plastics Laminates Committee Session

H. A. SPENCER, Knowlton Bros., Inc., Watertown, N. Y., *chairman*

14. "Decorative Laminates—Have They Really Changed?" by P. E. Fuerst, General Electric Co., Coshocton, Ohio.
15. "Test for Rate of Resin Penetration-Progress Report," by D. Gilmore, Brown Co., Berlin, N. H. (Progress Report, Project 763).
16. "Resin Solids Test" (Final Report—Project 764), by C. A. Siconolfi, Durez Plastics Div. of the Hooker Chemical Corp., Buffalo, N. Y. (Tentative).
17. "Resin Distribution Test" (Progress Report—Project 765), by C. J. Seiler, Behr Manning Corp., Troy, N. Y.
18. "Organo Phosphorous Epoxide Polymers," by L. M. Kindley.
19. "Modified Lignin Materials for Use with Phenolic Resins," by W. E. Morris, Polychemicals Division, West Virginia Pulp & Paper Co., Charlotte, S. C. (Tentative).

2:00 p.m. Synthetic Fibers Session

T. A. HOWELLS, The Institute of Paper Chemistry, Appleton, Wis., *chairman*

Synthetic Fiber Clinic. Prepared questions and answers and/or spontaneous unorganized discussion to foster a free technical exchange. Panel members: R. A. A. Hentschel, E. I. du Pont de Nemours & Co., Wilmington, Del., H. E. Shearer, American Viscose Corp., Marcus Hook, Pa., J. A. Waugh, Owens-Corning Fibreglas Corp., Ashton, R. I., R. T. Jackson, Riegel Paper Corp., Milford, N. J.

Reservations for hotel accommodations for the Plastics-Paper Conference may be obtained by writing to "15th TAPPI Plastics-Paper Conference, Hotel Syracuse, Syracuse, N. Y.," stating dates and times of both arrival and departure.

Eleventh Testing Conference

W. H. Aiken, Personal Products Corp., Milltown, N. J., general chairman

W. L. Cisler, The Detroit Edison Co.

of the Eleventh Testing Conference, has announced the program for the conference, which is to be held Sept. 27–30, 1960, at the Pantlind Hotel, Grand Rapids, Mich.

W. R. Willets, Titanium Pigment Corp., New York, N. Y., is general technical program chairman of the conference, and T. W. Lashof, National Bureau of Standards, Washington, D. C., is chairman of the relative humidity symposium, and C. E. Jakeway, Packaging Corp. of America, Grand Rapids, Mich., is in charge of local arrangements. Working with the conference committee are W. L. Kite, Lee Paper Co., Vicksburg, Mich., chairman, and J. D. Chadderdon, The KVP Co., Kalamazoo, Mich., vice-chairman, respectively, of the Kalamazoo Valley Section TAPPI. Others helping to make this conference successful are the following:

EXHIBITS
W. F. Bachelder, Testing Machines, Inc., Mineola, L. I., N. Y.
Richard Glaser, Mac Sim Bar Paper Co., Otsego, Mich.
HOSPITALITY AND REGISTRATION
D. E. Byro, Michigan Carton Co., Battle Creek, Mich.
L. R. Beeman, Watervliet Paper Co., Watervliet, Mich.
C. Russell, Allied Paper Corp., Kalamazoo, Mich.
F. Yankoviak, KVP Sutherland Paper Co., Kalamazoo, Mich.
HOTEL ARRANGEMENTS
R. Tubergen, Corn Products Sales Co., Grand Rapids, Mich.
J. B. Jasmin, Elliott Co., Grand Rapids, Mich.
MILL VISITS AND TRANSPORTATION
G. P. Ritzema, KVP Sutherland Paper Co., Parchment, Mich.

PROGRAM

MONDAY, SEPT. 26, 1960

9:00 a.m.–5:00 p.m. Steering Committee Meetings
5:00 p.m. Local Arrangements Committee
6:00 p.m.–9:00 p.m. Registration—Lobby

TUESDAY, SEPT. 27, 1960

8:00 a.m.–6:00 p.m. Registration—Lobby
9:00 a.m. Opening Session—Ballroom
2:00 p.m.–5:00 p.m. Committee Meetings (17)

WEDNESDAY, SEPT. 28, 1960

8:30 a.m.–7:30 p.m. Registration—Lobby
9:00 a.m.–12:00 noon. Session II—Ballroom

Symposium: Relative Humidity and Paper Test Methods

Moderator: H. A. BIRDSALL, Bell Telephone Laboratories, Murray Hill, N. J.

1. "Reasons for 65% R.H. and 20°C.," by W. H. Brecht, Institut fur Papierfabrikation, Technische Hochschule, Darmstadt, Germany.
2. "The Effect of Relative Humidity on the Stress-Strain Properties of Multiwall Paper," by G. A. Bernier and W. E. Carlson, St. Regis Paper Co., Carthage, N. Y.
3. "Hygroexpansivity of Tabulating Card Stock," by T. D. Callinan, J. S. Crimi, P. M. Schwartz, and L. H. Mirtz, International Business Machines Corp., Yorktown Heights, N. Y.
4. "The Effect of Relative Humidity on the Evaluation of Paper Properties," by W. A. Wink, The Institute of Paper Chemistry, Appleton, Wis.

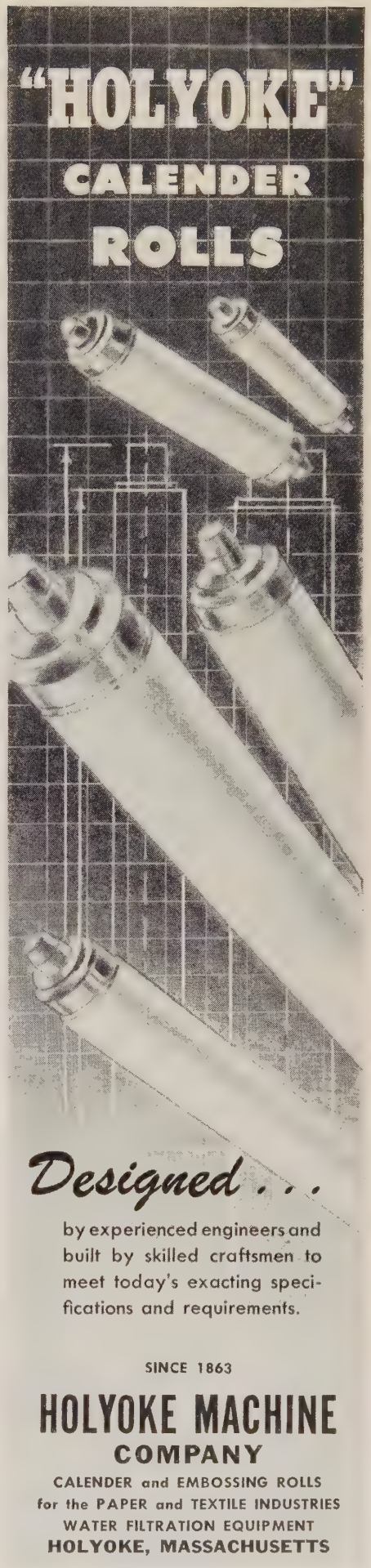
12:30 p.m. Luncheon (where you will)
2:00 p.m. Session II (contd.)—Ballroom

Discussion of these four papers tabled by J. d'A. Clark

Moderator: D. N. OBENSHAIN, West Virginia Pulp and Paper Co., Luke, Md.

5. "Some Developments in the Measurement of Relative Humidity," by A. C. Poulter, Albert E. Reed and Co., Ltd., Maidstone, Kent, England (to be presented by title).
6. "Standards in the Measurement of Relative Humidity," by A. Wexler, National Bureau of Standards, Washington, D. C.

Discussion of these two papers to be led by J. A. Van den Akker, The Institute of Paper Chemistry, Appleton, Wis.



7. "The Design and Control of Test Rooms and Small Ovens," by J. A. Cairns, The Printing, Packaging and Allied Trades Research Assoc., Leatherhead, Surrey, England (to be presented by title).
8. "A Room for Mill Control Testing of Paper," by L. L. Clapp, St. Regis Paper Co., Pensacola, Fla.
9. "The Constant Temperature Room as a Testing Facility: Its Design and Construction from a User's Viewpoint," by F. M. Gavan, Armstrong Cork Co., Lancaster, Pa.

Discussion of these three papers

6:00 p.m. Hospitality Hour (Cash Bar)—Kent State Room
7:00 p.m. Banquet—Ball Room

Jointly sponsored by Kalamazoo Valley Section TAPPI and the 11th Testing Conference

Toastmaster: W. H. Aiken; *Speaker:* W. L. Cisler, Detroit Edison Co., Detroit, Mich.

THURSDAY, SEPT. 29, 1960

8:30 a.m.–1:00 p.m. Registration—Lobby
9:00 a.m. Introduction by representative of State of Michigan, Water Conservation Dept.

Symposium: Water, the Most Important Nonfibrous Raw Material.—Ballroom

Moderator: E. W. Petrich, Howard Paper Mills, Inc., Urbana, Ohio

10. "Process Water," by R. K. Bamman, Champion Paper and Fibre Co., Hamilton, Ohio.
11. "Waste Water," by W. A. Flower, Howard Paper Mills, Inc., Urbana, Ohio.
12. "Boiler Water," by M. H. Borland, Mead Corp., Chillicothe, Ohio.

2:00 p.m. General Session—Ballroom

Moderator: J. R. Gunning, Provincial Paper, Ltd., Georgetown, Ont.

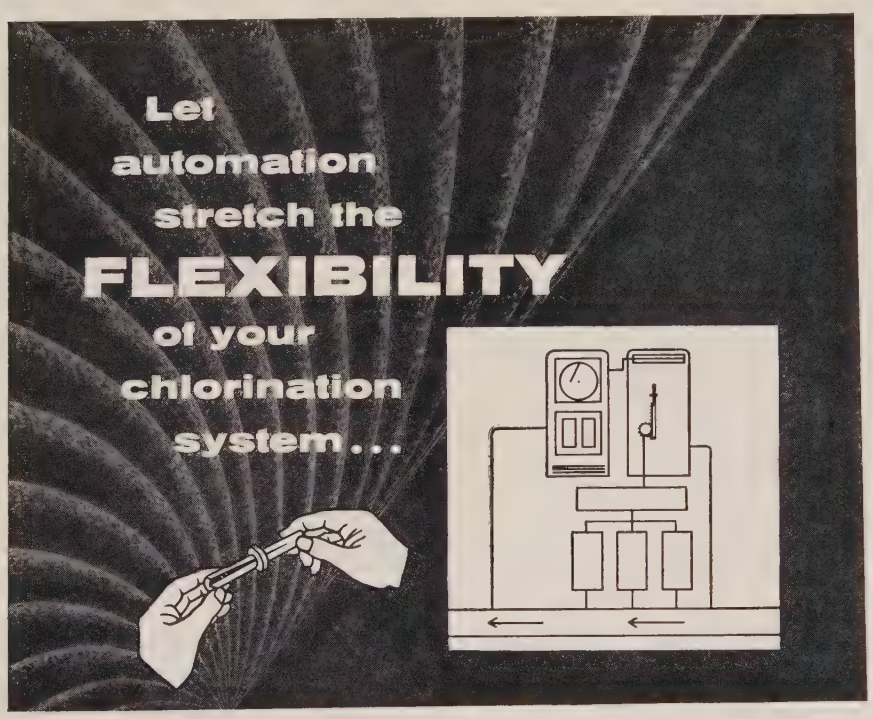
13. "Factors Influencing Testing of Gummed Tape," by E. Werle, Darling and Co., Chicago, Ill.
14. "Comparison of Proposed Test Methods for Measuring Adhesive Strength of Casein and Isolated Soy Protein in a Pigmented Coating," by L. E. Georgevits and W. L. Marino, The Borden Co., Bainbridge, N. Y.
15. "Survey of Sampling and Precision Requirements in Present TAPPI Test Methods," by C. A. Bicking, The Carborundum Co., Niagara Falls, N. Y.
16. "Measurement of Fiber Flexibility," by A. A. Robertson, E. Meindersma, and S. G. Mason, Pulp and Paper Research Institute of Canada, Montreal, Que.
17. "Development of Dirt Contribution Factors for Dirt in Pulpwood Chips," by E. Birkhimer, T. C. Rowland, H. B. Stanos, and B. E. Lauer, University of Colorado, Boulder, Colo.
18. "Identification of Coniferous Woods," by B. F. Kukachka, Forest Products Laboratory, Madison, Wis.
19. "Calibration of the IGT Printability Tester," D. S. Dixler, Air Reduction Co., Murray Hill, N. J.
20. "The IBM Carbon-Paper Intensity Tester," by R. S. Drown, International Business Machines Corp., Endicott, N. Y. (to be presented by title).

FRIDAY, SEPT. 30, 1960

8:30 a.m. Mill Visits

KVP Co. and Sutherland Paper Co., Kalamazoo, Mich. Return to Pantlind Hotel by 3:00 p.m. Twenty-one companies will exhibit equipment during the following hours:

Tuesday
8–9 a.m.; 12–2 p.m.; 4–6 p.m.
Wednesday
8–9 a.m.; 12–2 p.m.; 4–6 p.m.
Thursday
8–9 a.m.; 12–2 p.m.; 4–6 p.m.



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Fifth Deinking Conference

"Deinking Today and Tomorrow" is the theme for the Fifth Deinking Conference to be held at the Conway Hotel, Appleton, Wis., on Oct. 4–6, 1960. J. D. Allen, Bergstrom Paper Co., Neenah, Wis., is general conference chairman.

According to M. R. Kinne, Sealright-Oswego Falls Corp., Fulton, N. Y., technical program chairman, there will be two technical sessions, one on Wednesday morning on the subject of "Economics of Deinking," and one on Thursday morning on the subject of "The Future of Deinking."

There will also be a tour through the Bergstrom Paper Co. mill on Wednesday afternoon, and on Thursday afternoon there is to be a visit to The Institute of Paper Chemistry. G. C. Sisler, Bergstrom Paper Co., Neenah, Wis., is mill tour chairman.

Hotel reservations may be secured by writing to "TAPPI 5th Deinking Conference, Conway Hotel, Appleton, Wis.," and stating dates and times of both arrival and departure.

WEDNESDAY, OCT. 5, 1960

6:00 p.m.–8:00 p.m. Registration—Lake Superior Room
4:00 p.m. Steering Committee Meeting—Huron Room
8:00 p.m. Deinking Committee Meeting—Huron Room

THURSDAY, OCT. 6, 1960

9 a.m.–12 a.m. "Economics of Deinking"—Lake Michigan Room

Moderator: D. B. Geffken, Sealright-Oswego Falls Corp., Fulton, N. Y.

1. "Waste Paper Supply," by A. N. McLeod, The Institute of Paper Chemistry, Appleton, Wis.
2. "Economics of Deinked Stock Usage versus Virgin Pulp Usage," by J. L. Clouse, Oxford Paper Co., W. Carrolton, Ohio.
3. "Economics of Recovering in the Deinking System," by K. L. Maves, Bergstrom Paper Co., Neenah, Wis.
4. "Cost of Deinking?" (Author to be announced).

12:30 p.m. Luncheon—Crystal Room
2:00 p.m. Plant Trip: Bergstrom Paper Co., Neenah, Wis.
6:00 p.m. Hospitality Hour—Superior Room
7:00 p.m. Banquet—Crystal Room

Toastmaster: E. F. Andrews; *Speaker:* D. W. Bergstrom, Bergstrom Paper Co., Neenah, Wis.

FRIDAY, OCT. 7, 1960

8 a.m.–12 a.m. Registration—Lake Superior Room
9 a.m.–12 a.m. The Future of Deinking—Michigan Room

Moderator: J. C. Mills, Wyandotte Chemicals Corp., Wyandotte, Mich.

1. "Factors Tending to Increase Deinking Problems," by R. W. Kumler, Waste Paper Utilization Council, New York, N. Y.
2. "Practical Approaches to Solving Deinking Problems," J. W. Morrow, Newton Falls Paper Co., Newton Falls, N. Y.
3. "What Can Basic Research Do," by staff, The Institute of Paper Chemistry, Appleton, Wis.
4. "Growth in the Waste Paper Market," by H. J. Perry, Wilson, N. Y.

Luncheon—Crystal Room

2:00 p.m. Tour

The Institute of Paper Chemistry, Appleton, Wis.

Bergstrom Paper Co.

A mill tour of Bergstrom Paper Co., Neenah, Wis., is scheduled for Thursday afternoon, October 6. Arrangements

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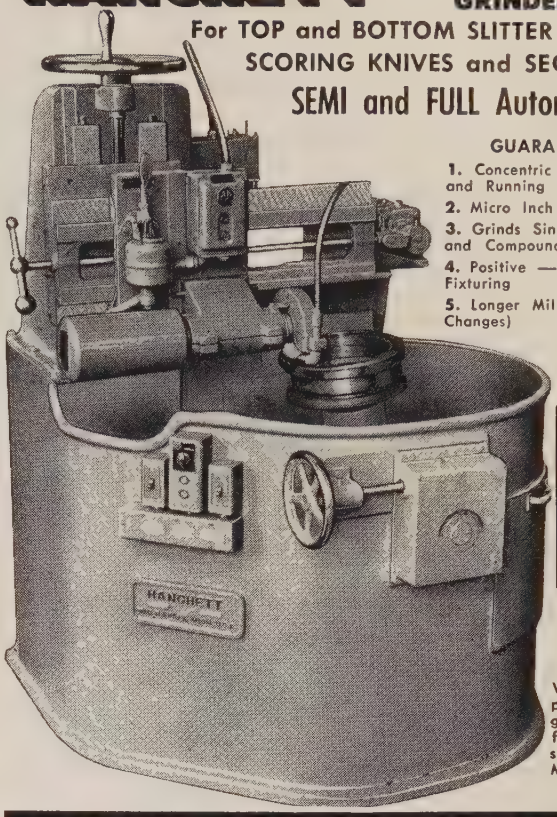

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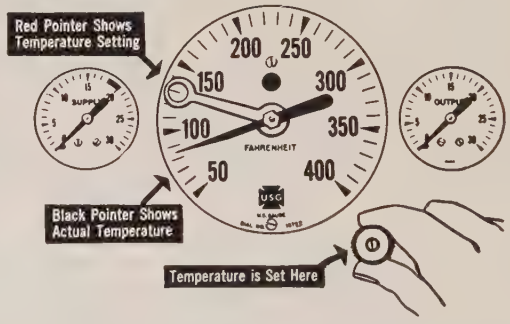

Stickle's latest automatic temperature control for individual wet end dryers improves the finish . . . helps prevent picking, curling and cockling on all types of paper and board. Maintains exact temperature desired in each dryer, within 1%, plus or minus. Assures gradual and uniform temperature increases. Fastest, simplest, most accurate wet end dryer control ever developed. Yet it costs less to install, operate and maintain. Predetermined results guaranteed.

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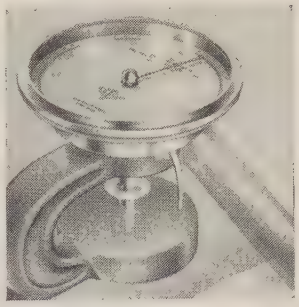

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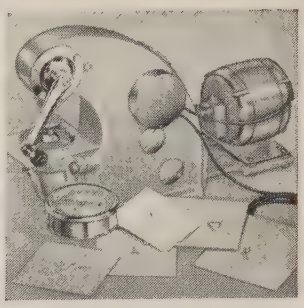

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have been made for transportation from the Conway Hotel, Appleton, to the deinking plant and paper mill in downtown Neenah and also to the finishing plant and main office on Highway 41, south of Neenah.

Bergstrom Paper Co. is a leading producer of uncoated book papers, office printing papers, offset for single and multicolor printing and converting papers.

The two Beloit paper machines have a combined output averaging about 150 tons per day of finished paper. Wire widths are 157 and 142 in. and papers ranging from 30 to 100 lb. basis weight (25 × 38—500) are produced. All book paper finishes from eggshell to English finish are manufactured. Two supercalender stacks (60 and 80-in.) are available for the production of S. C. finishes.

A modern continuous deinking plant processes about 160 to 170 tons per day of waste paper. Typical waste paper furnish consists of magazines, white and colored ledger, colored kraft, and tab cards.

A four-stage system of "side hills" provides countercurrent washing of brown stock.

The bleaching sequence is direct chlorination followed by two stages of high density hypochlorite treatment producing a pulp of 78 to 80 G.E. brightness.

Bird Vibrators are used for fine screening followed by five stages of centrifugal cleaning.

A modern finishing plant constructed in 1956 and located on Highway 41, south of Neenah, provides the very latest facilities for cutting, trimming, wrapping, and other finishing operations.

The Institute of Paper Chemistry

A tour of The Institute of Paper Chemistry, Appleton, Wis., is scheduled for Friday afternoon, October 7. Arrangements have been made for transportation from the Conway Hotel, Appleton, to The Institute of Paper Chemistry.

The Institute of Paper Chemistry, organized through the efforts of a group of Wisconsin pulp and paper executives and the trustees of Lawrence College, was chartered by the State of Wisconsin in 1929.

The principal functions of The Institute of Paper Chemistry are threefold.

The graduate school trains men in the basic sciences and technologies applicable to the pulp and paper industry. Graduates are fitted for technical positions in production and research and development work and ultimately may prepare themselves for higher executive or coordinating assignments.

Secondly, the Institute serves as a research center where the latest scientific equipment and knowledge is made available to the industry and where both fundamental and applied studies are conducted.

Finally, the Institute maintains a comprehensive library and acts as a central reservoir of information for the entire industry.

The campus at The Institute of Paper Chemistry occupies 32 acres and provides approximately 170,000 sq. ft. of working space.

The various laboratories and buildings at The Institute of Paper Chemistry will be open for inspection during the 5th TAPPI Deinking Conference.

Also on display will be the Dard Hunter Paper Museum. This collection, considered the world's finest, illustrates the art of papermaking from its invention in 105 A.D. to modern times. In addition to its thousands of specimens of early handmade papers, watermarks, and oriental decorative papers, the museum contains many rare books and manuscripts showing the evolution of papermaking and the introduction of science to the craft. Also on display are tools, appliances,

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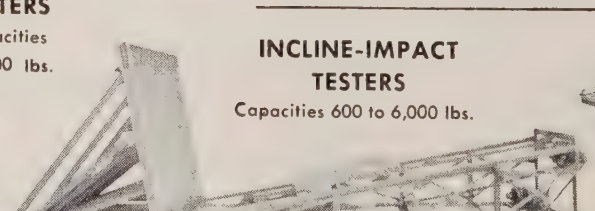
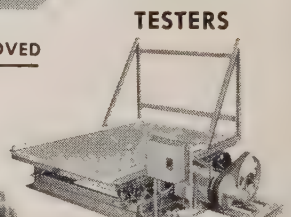


VIBRATION TESTERS



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and scale models of equipment from all parts of the world for the making of paper by hand.

The library at the Institute contains over 22,000 volumes in sciences and technology related to pulp and paper. The library currently subscribes to 450 scientific and technical periodicals. Also included are copies of about 40,000 United States patents on pulp and paper manufacture and related topics.

This specialized collection of scientific and technical literature is generally regarded as the most complete in the field of pulp and paper and thus offers exceptional opportunities to members of the staff and the students.

Tenth Corrugated Containers Conference

The Tenth Corrugated Containers Conference, scheduled for Oct. 10–13, 1960, at the Royal York Hotel in Toronto, Ont., is jointly sponsored by TAPPI and Technical Section, Canadian Pulp and Paper Association, Montreal, Que. R. A. Joss is advisor for the latter association.

R. W. Buttery, Bathurst Containers, Ltd., Montreal, Que., is general conference chairman and also chairman of TAPPI'S Corrugated Containers Division Production Committee. Mr. Buttery and R. H. McGee, Bathurst Power and Paper Co., Ltd., St. Laurent, Que., chairman of the Corrugated Containers Committee of the Technical Section, CPPA, are co-chairmen of the Technical Program Committee. Publicity is being scheduled by W. G. James, St. Lawrence Corp., Ltd., Montreal, Que., and local arrangements are under the direction of W. J. Hurrell, Hinde and Dauch, Ltd., Etobicoke, Ont. E. H. Head, Bathurst Containers, Ltd., Toronto, Ont., is in charge of registration. Hotel arrangements are under the direction of S. M. Johnson, Gair Paper Products Division, Continental Can Co. of Canada, Ltd., Toronto, Ont. H. F. Hughes, Hygrade Containers, Ltd., Rexdale, Ont., is in charge of hospitality arrangements. Mill tours have been arranged by H. S. Godwin, Bathurst Containers, Ltd., Toronto, Ont.

Messrs. Buttery and McGee have completed arranging the technical program which is as follows:

PROGRAM

SUNDAY, OCT. 9, 1960

1:00–9:00 p.m. ***Welcome Lounge—British Columbia Room***

MONDAY, OCT. 10, 1960

(Canadian Thanksgiving Day)

9:00 a.m.–8:00 p.m. ***Registration—Room B***

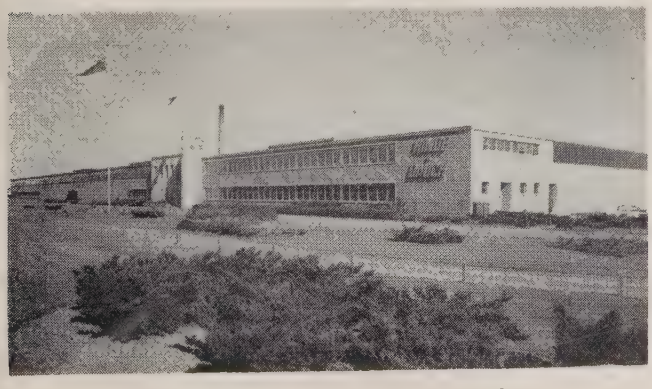
9:00 a.m. ***Steering & Advisory Committee—Saskatchewan Room***

9:00 a.m. ***Production Committee—Prince Edward Island Room***

2:00 p.m. ***Committee Meetings***

Engineering Committee—New Brunswick Room

Industrial Engineering Committee—Newfoundland Room



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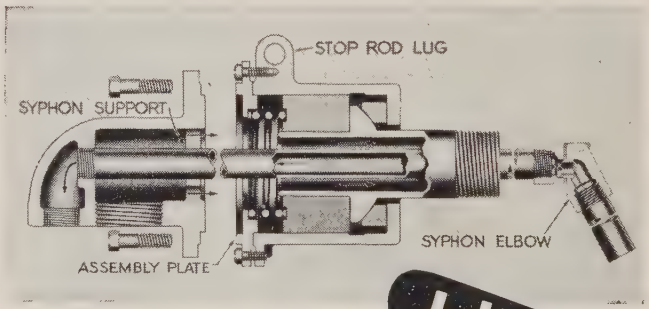

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Production Committee—Prince Edward Island Room
Quality & Process Control Committee—Algonquin Room
Raw Materials Committee—Alberta Room
Container Testing—Nova Scotia Room

5:30–7:30 p.m. Reception—British Columbia Room. Courtesy Equipment Manufacturers

TUESDAY, OCT. 11, 1960

8:00 a.m.–5:00 p.m. Registration—Room B

9:00 a.m. Session I, Meeting Modern Trends for Improved Printing on Corrugated Board—Concert Hall

Moderator: D. M. Davis, Hercules Box Co., Columbus, Ohio

1. "Printing Press Rollers Designed for Corrugated Printing," by G. A. Browne, Permaflex Industries, Ltd., Toronto, Ont.
2. "Printing Inks for Corrugated Board," by R. Reid, General Printing Ink Co., Cincinnati, Ohio.
3. "Printing Dies for Corrugated Board," by H. Devon, Jas. A. Matthews & Co., Pittsburgh, Pa.

12:30 p.m. Luncheon (Informal)—Canadian Room

2:00 p.m. Session II, Meeting Modern Trends for Improved Printing on Corrugated Board—Concert Hall (contd.)

Moderator: D. M. Davis

1. A moving picture will be shown demonstrating the proper adjustments of printing press rollers, printing inks, and printing dies and their use to obtain top quality and to reduce costs.
2. Panel to discuss questions from the floor on the morning and afternoon theme "Meeting Modern Trends for Improved Printing on Corrugated Board":

G. A. Browne, Permaflex Industries
R. Reid, General Printing Ink Co.
H. Devon, Jas. A. Matthews & Co.
G. A. Bidgood, Art Director, Bathurst Containers, Ltd.
W. Stevens, Hygrade Containers, Ltd.
R. V. G. Corbett, Supervisor of Printing Supplies, Hinde & Dauch, Ltd.
C. Barnes, General Foreman, Gair Paper Products, Div. of Continental Can Co. of Canada, Ltd.

5:30–7:30 p.m. Reception—Ballroom. Courtesy Canadian Corrugated Manufacturers

WEDNESDAY, OCT. 12, 1960

8:00 a.m.–2:00 p.m. Registration—Room B

9:00 a.m. Session III, New Developments in Packaging—Concert Hall

Moderator: H. J. Ostrowski, Hinde & Dauch, Ltd., Toronto, Ont.

1. "Corrugated Containers Under Refrigeration," by A. C. Beardsell, The Mead Corp., Cincinnati, Ohio.
2. "Bulk Packaging," by T. C. Kitchell, Union Bag-Camp Paper Corp., New York, N. Y.
3. "Evaluation of Packages by Laboratory and Field Tests," by J. G. Turk and R. Maxson, Glass Container Manufacturers Institute, Inc., East Lansing, Mich.
4. "An Underwater Beam Strength Test for Waxed Corrugated Board," by D. S. Brown, C. J. Kremer, and A. C. Smith, Jr., The Atlantic Refining Co., Philadelphia, Pa.

12:30 p.m. Luncheon—Canadian Room

Toastmaster: B. Mendlin

2:00 p.m. Session IV, General—Concert Hall

Moderator: H. S. Inman, Gair Paper Products Div. of Continental Can Co. of Canada, Ltd., London, Ont.

1. "The Bathurst Method for Determination of Corrugator Starch Consumption," by J. G. Reynolds, Bathurst Power and Paper Co., Ltd., Montreal, Que.
2. "Evaluation of New Corrugating Starches—Case Histories," by D. B. Black, Gair Paper Products Div. of Continental Can Co. of Canada, Ltd., Toronto, Ont.
3. "Electrical Drive Maintenance—A Key Factor in Production Costs," by J. W. Landers, Reliance Electric and Engineering, Cleveland, Ohio.

Evening: Free to enjoy Toronto as you wish.

PLANT TOURS

Mr. Godwin has arranged an excellent tour of three corrugated box plants in the Toronto area, Hinde and Dauch, Bathurst Containers, Ltd., and Hygrade Containers. These are three modern plants and will surely excite the interest of those attending the conference. The plant tour program is as follows:

Thursday, Oct. 13, 1960

8:30 a.m. Tours to the following three modern corrugated container plants:

1. Hinde & Dauch, Ltd. Choice of visiting container plant at Etobicoke, Ont., or Testing Laboratory at Hanna Ave., Toronto.
2. Bathurst Containers, Ltd., Hamilton, Ont.
3. Hygrade Containers, Ltd., Rexdale, Ont.

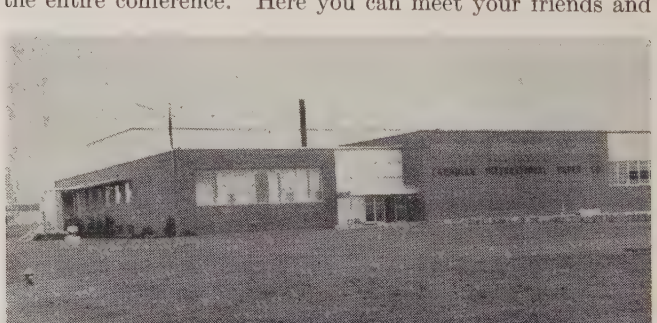
Lunch will be served at Brant Inn in Burlington, Ont., located on the shore of Lake Ontario following the Bathurst tour.

LADIES' PROGRAM

Mr. Hughes, as a major portion of his Hospitality Committee duties, has arranged a most interesting program for the ladies who will be attending the conference with their husbands. The Ladies' Program is as follows:

Sunday, Oct. 9, 1960

Hospitality Room (British Columbia Room) open during the entire conference. Here you can meet your friends and



Hygrade Containers, Ltd., Rexdale, Ont.

Bathurst Containers, Ltd., Hamilton, Ont.

the other wives attending the conference as well as obtain information and assistance from the staff on duty.

MONDAY, OCTOBER 10 TO THURSDAY, OCTOBER 13, INCLUSIVE

8:30–10:30 a.m. Continental Breakfast will be served to all ladies in the British Columbia Room each day during the conference. Tours will also originate from this room.

2:30 p.m. Film—"Designed to Go Places."

5:30–7:30 p.m. Reception for delegates and their wives, courtesy machinery manufacturers.

TUESDAY, OCT. 11, 1960

10:30 a.m.–4:00 p.m. Tour of the main attractions of the city of Toronto with lunch at Casa Loma, Toronto's famous castle.

5:50–7:30 p.m. Reception for delegates and their wives, courtesy Canadian Corrugated Container Manufacturers.

WEDNESDAY, OCT. 12, 1960

10:30 a.m.–5:00 p.m. Tour of Niagara Falls with lunch overlooking the falls.

THURSDAY, OCT. 13, 1960

Shopping.

Pulp Bleaching Conference

As a consequence of the continuing realization of its responsibility to the pulp and paper industry, the Pulp Purification Committee, under the chairmanship of F. Kraft, Marathon Division of the American Can Co., Menasha, Wis., formulated plans slightly over a year ago to present a conference dealing only with pulp bleaching in all its ramifications.

One of the contributing factors to the conference plans was the fact the committee had already undertaken the revision of the TAPPI Pulp Bleaching Monograph No. 10 and it was strongly felt that the open forum provided at a pulp bleaching conference would strengthen the effectiveness of the subject coverage for the proposed revision of the monograph.

Accordingly, under the general direction of F. Kraft, as conference chairman; F. P. Doane, Jr., Bergstrom Paper Co., Neenah, Wis., as advisor; and R. J. Auchter, Kimberly Clark Corp., Neenah, Wis., as technical program chairman; the context of the technical program was developed.

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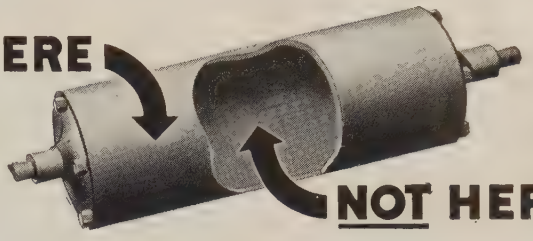

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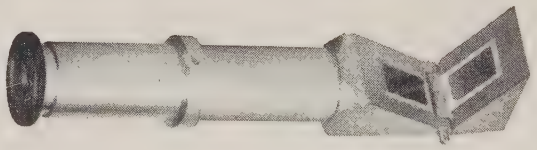

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Conference Committee: (standing) J. D. Wethern, Riegel Paper Corp., Acme, N. C.; R. J. Auchter, Kimberly-Clark Corp., Neenah, Wis.; H. O. Teeple, TAPPI, New York, N. Y. (Sitting) J. F. Whalen, Combined Locks Paper Co., Combined Locks, Wis.; F. Kraft, American Can Co., Menasha, Wis.; F. P. Doane, Jr., Bergstrom Paper Co., Neenah, Wis.

Co., Acme, N. C., and J. F. Whalen, Combined Locks Paper Co., Combined Locks, Wis., Mr. Auchter arranged a technical program covering practically all of the significant aspects of pulp bleaching. Both international and national experts in various phases of pulp bleaching were invited to present papers at the conference and the extent of both their intensive coverage of the subject is indicated by the following titles and abstracts of papers presented at the conference held at the Edgewater Beach Hotel, Chicago, Ill., June 14–16, 1960.

1. **"Theory of the Optical Properties of Pulp,"** by J. A. Van den Akker, The Institute of Paper Chemistry, Appleton, Wis.

Although some of the optical properties of paper may not be simply related to those of pulp (e.g., gloss, transparency, opacity), the latter have a very important bearing on the color and other appearance characteristics of paper. The interaction between ultraviolet, visible and infrared radiation and cellulose in solution and in sheet and fibrous form permits both scientific and technical studies of pulp and affords fundamental data relating to the maximum attainable whiteness of the end product. The measurable optical properties of pulp (spectral reflectances and spectral transmission) are related through the modified Kubelka-Munk theory to the spectral specific absorption and scattering coefficients of the pulp; the latter are, in turn, related to the spectral specific absorption and scattering coefficients of the pulp components. Graphical and tabular aids exist for the application of theory to practical problems. Specialized reflectances such as "standard brightness" serve as quick and precise measures of the whiteness potential of a pulp, and are otherwise of technical value. Even though such reflectances are not determined with monochromatic light, they are related, through theory, to specific absorption and scattering coefficients (for heterogeneous light) in a very useful manner.

2. **"Determination of Optical Properties of Pulp,"** by J. H. E. Herbst and H. Krässig, Industrial Cellulose Research, Ltd., Hawkesbury, Ont.

Many optical properties of pulp are described by the absorption and scattering coefficients. A new method for the determination of these coefficients is presented. When pulp is dyed under suitable conditions, the plot of $(1\text{-}R_{oo})2/2\ R_{oo}$ against the amount of dye used is linear, in agreement with the Kubelka-Munk equation. The slope of this plot gives the scattering coefficient, and the absorption coefficient is calculated from the scattering coefficient and the reflectivity of the undyed material. Advantages claimed are simplicity of procedure, flexibility of the conditions under which the method is used, and the fact that the results are not dependent on the basis weight. A disadvantage is that the results obtained are relative only.

3. **"Brightness Reversion,"** by I. H. Spinner and W. H. Rapson, University of Toronto, Toronto, Ont.

A critical review of the literature of the last twenty years on brightness reversion shows that the results of several investigators which appear to conflict can be reconciled.

The effect of carbonyl and carboxyl groups in carbohydrates on color reversion has been established by the work of several investigators. Although there is some apparent disagreement on the magnitude of these effects, consideration of the nature of the tests used has permitted these differences to be resolved.

The effect of the minor constituents of pulp such as lignin, resin, fillers, and metal ions are also critically reviewed in the light of recent investigations.

4. **"The Chemistry of the Acidic Chlorination of Wood Pulp,"** by C. Dence, State University College of Forestry, Syracuse University, Syracuse, N. Y.

A description of the reaction of chlorine with simple lignin-like structures to serve as a basis for an evaluation of chemical changes occurring during the chlorination of wood pulp and the effect of chlorination reactions on subsequent bleaching steps.

5. **"The Alkaline Extraction of Wood Pulp,"** by M. Wayman, Sandwell International, Ltd., Vancouver, B. C.

This paper discusses alkaline extraction as a stage in bleaching and purification of wood pulp. The caustic to pulp ratio, temperature, time, and consistency of extraction differ with the raw material and with the product desired. Alkaline ex-

Overseas Visitors Reception: M. R. Schenck, Zellstoff Waldhof, Wisbaden, Germany; J. N. McGovern, Parsons & Whittemore, Inc., New York, N. Y.; K. Thierfelder, Zellstoff Waldhof, Kostheim, Germany; F. Kraft, Marathon Corp., Menasha, Wis.; W. Gaertner, Degussa, Frankfurt, Germany; R. Schepp, Aschaffenburger Zellstoffwerke, Redenfelden, Germany; L. J. Rys, Cellulosa de Chihuahua, Mexico

Overseas Visitors Reception: F. Kraft, Marathon Corp., Menasha, Wis.; J. Richter, Kamyr, Karlstad, Sweden; K. A. Zachariasen, Buckeye Cellulose Corp., Memphis, Tenn.; J. R. Salvesen, Marathon Corp., Rothschild, Wis.; A. Wretne, Rosenblad Corp., New York, N. Y.

traction of kraft pulps, and of sulfite paper pulps is usually quite mild, whereas the preparation of dissolving pulps requires more intensive treatment. Hot dilute caustic soda extraction and low temperature concentrated caustic soda extraction can be used separately or in combination to produce more highly purified wood pulp. Cold caustic soda extraction as a stage in purification is necessary where very pure cellulose is desired from either sulfite or kraft wood pulp. The caustic extraction stage also controls resin in pulp, usually assisted by the use of additives, and recent work suggests that it may, under some circumstances, be used to control brightness and viscosity by the incorporation of a small amount of bleach.

6. **"Hypochlorite Bleaching,"** by J. M. McEwen, Weyerhaeuser Timber Co., Everett, Wash.

Hypochlorite is still much used as a bleaching agent for pulp because of low cost, ability to bleach dirt specks, and ability to uniformly degrade dissolving pulps. The reaction of hypochlorite with pulp is a complicated one in which lignin, cellulose, and other organic components are simultaneously oxidized and chlorinated. The effect of the hypochlorite bleaching variables of temperature, pH, bleaching time, and concentration of hypochlorite is discussed. Sodium and calcium hypochlorite are compared for both paper pulps and dissolving pulps.

7. **"Peroxide Bleaching of Kraft Pulps,"** by N. Hartler, The Central Laboratory of the Swedish Cellulose Industry, Swedish Forest Products Research Laboratory, Stockholm, Sweden.

The stability of alkaline solution of hydrogen peroxide is shown to be influenced by the material in the store bottle as well as by the presence of certain metallic ions. Besides magnesium sulfate and silicate, chelating substances (e.g., EDTA) have a stabilizing action. Sufficient amount to chelate all metallic ions present has to be added for successful stabilization.

In final stage bleaching of sulfate pulps hydrogen peroxide produces a pulp of maximum brightness when applied at a pH of approximately 11. When sufficient amount of silicate is present as stabilizer a surprisingly low percentage of the added peroxide is consumed. A certain excess of peroxide has, however, to be present at the end of the bleaching. A high pulp consistency and a high temperature is favorable from bleaching point of view. The most attractive feature of a peroxide bleached pulp is the low brightness reversion. The comparatively high price of peroxide particularly in Sweden seems, however, at the present time to form a barrier preventing the more common use of peroxide in pulp bleaching.

8. **"Status and New Development in Peroxide Bleaching of Pulps,"** by F. L. Fennell, G. E. Smedberg, and N. J. Stalter, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

New developments in the use of peroxide for bleaching cold soda, groundwood, and kraft pulp are presented.

Typical process layouts for peroxide bleaching cold soda pulp in refiners and towers are given, together with an outline of the chemical requirements and the bleaching results. Data obtained in the refiner bleaching process show that under certain conditions there is a significant bleaching advantage when sulfuric acid is used for partial neutralization of the caustic-treated chips just prior to, or simultaneously with, the peroxide addition as the chips enter the refiner. Laboratory data also compare the bleachability of cold soda pulps prepared from representative hardwood pulp mixtures from the South, Northeast, and North Central areas.

A high-temperature, groundwood bleaching process has been developed in the du Pont laboratory using peroxide at 200°F. for a period of 10 min. to produce groundwood with a brightness comparable to that obtained with conventional processes operating at 100–110°F. This high-temperature peroxide bleaching process was developed primarily to meet the needs of the smaller groundwood mills for reduced capital investment in line with reduced tonnage requirements. The effects of the common variables such as time, and concentration are given.

Data are presented showing that peroxide can be used with technical and economic advantage in five- and six-stage bleaching processes operating with one or two stages of chlorine dioxide. The five-stage process at Marathon Southern, Naheola, Ala.—chlorination, caustic extraction, calcium hypochlorite bleach, chlorine dioxide, peroxide—is described; the chemical concentrations employed and the bleached pulp results are included.

9. **"Deresination of Sulfite Pulps with Non-Ionic Surfactants,"** by J. W. Wilson, D. O'Meara, and R. M. L. Paterson, Columbia Cellulose Co., Ltd., Prince Rupert, B. C.

Three species of Northern British Columbia coniferous woods contain 1.5 to 2.0% alcohol-benzene solubles. This is reduced to 0.7% in calcium-base sulfite cooking and to 0.3 to

Overseas Visitors Reception: R. P. Whitney, Institute of Paper Chemistry, Appleton, Wis.; G. A. Nichols, New Zealand Forest Products, Ltd., Penrose, Auckland, New Zealand; W. H. Rapson, University of Toronto, Toronto, Can.; J. F. Smith, Inveresk Research Laboratories, Weybridge, Surrey, England; J. Buglass, Westfield Paper Co., Ltd., Scotland; J. S. Hart, St. Lawrence Corp., Ltd., Montreal, Que.; S. J. Auchter, Kimberly Clark Corp., Neenah, Wis.

Moderator and Speakers, Session I: F. Kroft, Marathon Div., American Can Co., Manasha, Wis.; J. A. Van den Akker, The Institute of Paper Chemistry, Appleton, Wis.; J. H. E. Herbst, Industrial Cellulose Research, Ltd., Hawkesbury, Ont.; I. H. Spinner, University of Toronto, Toronto, Ont.

0.4% in a subsequent hot caustic extraction. By adding surfactants during caustic extraction the resin level can be controlled at any point down to 0.05%. Ether linked nonionics have been found to be the most effective class of additives. Homologous series of polyethenoxy tridecanol, nonyl phenol, dodecyl phenol and dinonyl phenol condensates with varying mole ratios of ethylene oxide were examined as additives. Each hydrophobic base gave a characteristic deresination efficiency related to molecular size. For all series investigated efficiency was greatest at a common hydrophobic base content which was 25 to 35% by weight dependent on extraction temperature. The most effective temperature was 100 to 110°C. Level of addition had a minor effect on selection of the optimum composition.

Cottonwood behaves differently in deresination. The initial 2.0 to 2.5% resin is reduced to 1.0% in sulfite cooking and to 0.6 to 0.7% in hot caustic extraction. Wood seasoning and caustic strength have a pronounced effect on the final resin content. Surfactant addition was much less effective than with coniferous pulps and a molecule containing 35% hydrophobic base gave optimum results.

10. **"Studies on the Mechanism of Chlorine Dioxide Bleaching,"** by K. Kakehi, R. A. Murphy, and V. Sarkanen, State University College of Forestry, Syracuse University, Syracuse, N. Y.

The partial conversion of certain lignin model compounds to cyclic peroxides by the action of aqueous chlorine dioxide has been established. The possible mechanism of such reactions as well as the significance of peroxidic intermediates in the bleaching and delignification processes of wood and pulp lignins are discussed.

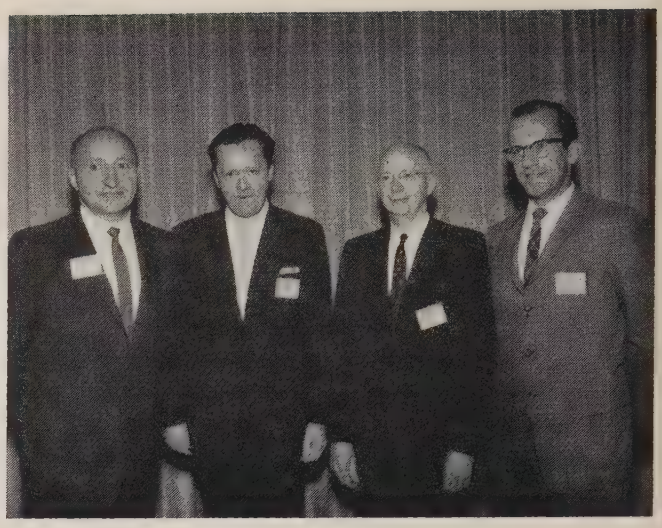
11. **"Chlorine Dioxide Bleaching,"** by W. H. Rapson, University of Toronto, Toronto, Ont.

The various ways of using chlorine dioxide in pulp bleaching sequences are critically evaluated. The optimum conditions for obtaining maximum brightness, minimum color reversion and maximum strength retention at minimum cost are reviewed.

The advantages of combinations of chlorine dioxide with several other bleaching agents are discussed. Results of a current investigation of various methods of bleaching to 92 G.E. brightness are presented.

12. **"Aspects on the Bleaching of High Yield Pulps,"** by H. W. Giertz, The Technical University of Norway, Trondheim, Norway

Moderator and Speakers, Session II: R. J. Stevens, Canadian International Paper Co., Montreal, Que.; C. Dence, State University College of Forestry, Syracuse, N. Y.; M. Wayman, Sandwell International, Ltd., Vancouver, B. C.; J. M. McEwen, Weyerhaeuser Timber Co., Everett, Wash.



Moderator and Speakers, Session III: F. Casciani, P. H. Glatfelter Co., Spring Grove, Pa.; N. Hartler, The Central Laboratory of the Swedish Cellulose Industry, Stockholm, Sweden; F. L. Fennell, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.; R. M. L. Patterson, Columbia Cellulose Co., Ltd., Prince Rupert, B. C.

Moderator and Speakers, Session IV: F. P. Doane, Jr., Bergstrom Paper Co., Neenah, Wis.; K. V. Sarkanen, State University College of Forestry, Syracuse University, Syracuse, N. Y.; W. H. Rapson, University of Toronto, Toronto, Ont.; H. W. Giertz, The Technical University of Norway, Trondheim, Norway

Moderator and Speakers, Session V: H. L. Crosby, The M. W. Kellogg Co., New York, N. Y.; R. L. Allen, Jr., Eastern Engineering Co., Atlanta, Ga.; G. A. Nicholls, New Zealand Forest Products, Ltd., Penrose, Auckland, New Zealand

The problem of bleaching high yield pulps is to obtain high brightness (<80 G.E.) without dissolving the lignin. This cannot be performed with ordinary bleaching agents as chlorine, hypochlorite, and chlorine dioxide, because these agents form colored substances with the lignin, which have to be further attacked. A final high brightness can therefore not be achieved before all lignin is dissolved.

It is well known that peroxides have a specific decoloring action on wood without reacting with the lignin under the formation of colored substances. Chlorates are also said to bleach without appreciable lignin losses. In the present work these agents have been used for bleaching high yield neutral sulfite and cold soda pulps.

It was found that sodium chlorate is not a suitable "surface" bleaching agent because chlorite, chlorine dioxide, and some chlorine are formed. During bleaching a heavy discoloration takes place and a final high brightness can only be obtained by dissolving the major part of the lignin. With peroxides, however, some promising results were obtained. It was found that pulps having been discolored during the pulping operation, most probably by lignin condensation, were impossible to bleach without dissolving all the lignin. If, however, the cooking could be performed under such conditions that no extra color was formed, the "surface" bleaching was quite good.

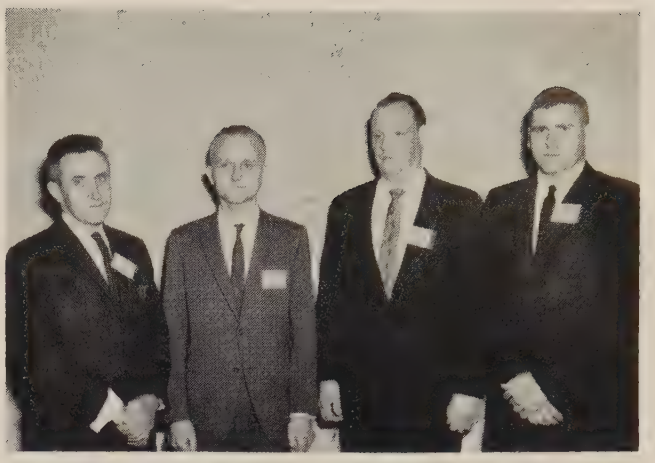
By cooking birchwood with a bisulfite cooking liquor to a yield of about 85% and bleaching with 2 to 3% peroxide and 1% sodium hyposulfite, a bleached pulp of 81 G.E. and a yield of more than 80% was obtained.

13. **"Materials of Construction for Modern Pulp Bleaching Systems,"** by R. L. Allen, Jr., Eastern Engineering Co., Atlanta, Ga.

Materials of construction for piping, instruments, and equipment, used in the pulp bleaching systems and their auxiliary chemical handling and preparation systems will be discussed. Factors governing the selection of a material for a particular service will be presented. The bleaching processes covered are chlorination, caustic extraction, hypochlorite bleaching, chlorine dioxide bleaching, and peroxide bleaching.

14. **"Laboratory Bleaching of *Pinus Radiata* Kraft Pulp,"** by G. A. Nicholls, New Zealand Forest Products, Ltd., Penrose, Auckland, New Zealand

Unbleached radiata pine kraft pulp has been bleached by various sequences. In relation to using a three tower plant, a chlorination-alkali extraction-hypochlorite-chlorination-peroxide-hypochlorite process has been examined and found



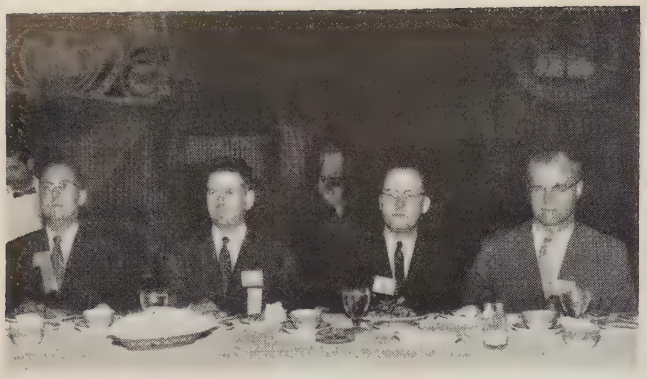
Moderator and Speakers, Session VI: H. W. Bialkowksy, Weyerhaeuser Timber Co., Longview, Wash.; R. G. Meret, MacMilan, Bloedel & Powell River, Ltd., Powell River, B. C.; M. H. Voelker, The Institute of Paper Chemistry, Appleton, Wis.; R. H. Boehm, Kimberly-Clark Corp., Neenah, Wis.

to give 85 to 86 G.E. brightness pulp, the strength of which has been determined from handsheets prepared from Lamnpe milled stock. When bleaching by chlorination-alkali extraction-hypochlorite-chlorine dioxide it was noted that a higher hypochlorite pH led to higher ultimate brightness, and that a chlorine dioxide stage substituted for the last three stages in the above six-stage sequence gave pulp of 86 to 88 G.E. brightness with better stability to heat aging. Pulp strength has been determined and compared with that of unbleached and six-stage bleached pulps. From experiments to determine the advantage of including small amounts of chlorine dioxide with chlorine during chlorination, it has been found that viscosity gain is related to the quantity of chlorine applied.

15. **"The Use of Reducing Agents,"** by J. L. Keays, MacMillan, Bloedel and Powell River, Ltd., Powell River, B. C.

Of several reducing agents now utilized for brightening or for heating bleached pulps (hydrosulfites, sulfites and bisulfites, or sulfur dioxide), zinc hydrosulfite appears to be most widely used, particularly in the brightening of groundwood pulps; this is understandable on a basis of its brightening effect, relatively low cost, and the fact that its use is not

Moderator and Panel Members: Session VII: R. P. Whitney, Institute of Paper Chemistry, Appleton, Wis.; N. Hartler, Swedish Forest Products Research Laboratory, Stockholm, Sweden; W. H. Rapson, The University of Toronto, Toronto, Ont.; H. W. Giertz, The Technical University of Norway, Trondheim, Norway; R. J. Stevens, Canadian International Paper Co., Montreal, Que.; J. A. Van den Akker, Institute of Paper Chemistry, Appleton, Wis.



Tuesday Luncheon: H. O. Teeple, TAPPI, New York, N. Y.; L. H. Crosby, M. W. Kellogg Co., New York, N. Y.; R. P. Whitney, Institute of Paper Chemistry, Appleton, Wis.; R. J. Stevens, Canadian International Paper Co., Montreal, Que.

Tuesday Luncheon: R. P. Whitney, The Institute of Paper Chemistry, Appleton, Wis.; R. J. Stevens, Canadian International Paper Co., Montreal, Que.; J. D. Wethern, Riegel Paper Corp., Acme, N. C.; F. P. Doane, Jr., Bergstrom Paper Co., Neenah, Wis.; J. N. McGovern, Parsons & Whittemore, Inc., New York, N. Y.

accompanied by a loss in pulp yield. A groundwood brightness gain of 12 to 14 G.E. units can be obtained with 2–3% zinc hydrosulfite (based on moisture free weight), depending on the temperature (up to 180°F.) reaction time (0.5–4 hr.), rapidity and uniformity of mixing, wood species, and pH.

Sodium hydrosulfite gives much the same brightening results as are obtained with zinc hydrosulfite. However, this chemical appears less stable than the zinc salt, particularly at low pH levels, and this instability might limit its brightening effectiveness.

Sodium sulfite and sodium bisulfite are also used for obtaining a moderate brightness increase in groundwood (1 to 2.4 G.E.), either alone or in sequence with zinc hydrosulfite.

Sulfur dioxide, sodium bisulfite, and sodium metabisulfite are used as acidifying agents and as "antichlors" after the final bleaching stage in the bleaching of a variety of chemical pulps in order to eliminate the effect of residual chlorine on pulp strength and brightness permanence.

Corrosion problems, particularly on fourdrinier wire and drier felt life, may be encountered with the use of both sulfites and hydrosulfites. There is still inadequate knowledge on the true extent of corrosion arising from the use of the hydrosulfites, and on the most economical means of reducing it.

Sodium borohydride is a strong reducing agent which shows promise as a groundwood brightening agent and for application in improving the brightness and the brightness stability of chemical pulps. However, because of its present high cost, sodium borohydride has not been used commercially in groundwood brightening or as a part of pulp bleaching.

16. **"Effect of Bleaching on Papermaking Properties,"** by M. H. Voelker, The Institute of Paper Chemistry, Appleton, Wis.

Generally, the primary purpose of bleaching is to brighten or whiten the pulp. However, in some cases the strength and other papermaking qualities of a pulp may also undergo considerable change. In other cases the strength characteristics may remain essentially unchanged. Because of the many variables involved, practically every species of pulp and type of bleaching sequence has usually been considered as an independent study in itself. Recently, however, certain generalized concepts and principles are beginning to emerge from rapidly expanding research. On this basis it is possible to sketch a general outline of the overall bleaching and papermaking picture, and indicate some of the basic factors and sources of factors which appear to be involved. This has been done by a stepwise approach which includes:

1. A general description of the ways in which bleaching chemicals affect the composition and characteristics of pulps.
2. A consideration of the effects of pulp composition and characteristics on the basic papermaking qualities of the fibers.
3. A consideration of the manner in which the basic qualities of the fibers ultimately influence the actual papermaking properties.

17. **"The Effect of the Papermaking Process on the Optical Properties of Paper,"** by R. H. Boehm, Kimberly-Clark Corp., Neenah, Wis.

The optical properties of finished paper are dependent on the materials added to the component pulps and on the physical treatments given the pulps in the papermaking process as well as the optical properties of the component pulps themselves. This discussion is a review of some of these factors in papermaking which do influence the final optical properties of the paper. Included are: beating and refining, pulp blending, addition of fillers, dyes and bonding agents, two-sidedness, wet pressing, draws and tensions, drying, and calendering. These factors are reviewed in terms of their effects on the scattering and absorption of light and the consequent effects on opacity, brightness, and color.

18. **Panel: "Progress in Pulp Bleaching"** Moderator, R. P. Whitney, The Institute of Paper Chemistry, Appleton, Wis.

Panel:
H. W. Giertz, The Technical University of Norway, Trondheim, Norway
N. Hartler, Swedish Forest Products Research Laboratory, Stockholm, Sweden
W. H. Rapson, The University of Toronto, Toronto, Ont.
R. J. Stevens, Canadian International Paper Co., Montreal, Que.
J. A. Van den Akker, The Institute of Paper Chemistry, Appleton, Wis.

This panel of internationally known authorities on pulp bleaching will consider timely questions such as:

"Where do we stand today in pulp bleaching? Are we doing an adequate job? Are we progressing toward better performance? Is our rate of progress satisfactory? What are the 'roadblocks' to further progress? What are we doing about these roadblocks?

"Is our research and development geared too much to present-day technology and presently-employed bleaching agents? What problems in bleaching and purification will be posed by new developments in other areas of pulp and paper technology? Do we have an understanding of the mechanisms of bleaching which is adequately concerned with audacious thinking regarding entirely new approaches to bleaching?"

The obvious value of the technical program was indicated by the fact that 287 men attended the conference. It is of interest to note these included 57 people from other countries outside the United States. These people, who contributed greatly to the success of the conference by their attendance and by their comments during the several discussion sessions, are listed below.

Tuesday Luncheon: F. Kraft, American Can Co., Menasha, Wis.; R. J. Auchter, Kimberly-Clark Corp., Neenah, Wis.; P. E. Nethercut, TAPPI, New York, N. Y.; J. F. Whalen, Combined Locks Paper Co., Combined Locks, Wis.

Tuesday Luncheon: J. F. Whalen, Combined Locks Paper Co., Combined Locks, Wis.; J. M. McEwen, Weyerhaeuser Timber Co., Everett, Wash.; F. Cascianni, P. H. Glatfelter Co., Spring Grove, Pa.; L. B. Taylor, Columbia Southern Chemical Corp., Pittsburgh, Pa.; A. J. Winchester, TAPPI, New York, N. Y.

Registrants from Other Countries

1. Andrews, D. H., Canadian Industries, Ltd., McMasterville, Que.
2. Aschim, O. K., Dryden Paper Co., Ltd., Dryden, Ont.
3. Avela, E., Oy Kaukas AB, Lappeenranta, Finland
4. Bentley, H. W., Canadian Industries, Ltd., Montreal, Que.
5. Berg-Johannessen, P., Dryden Paper Co., Ltd., Dryden, Ont.
6. Buglass, J., Westfield Paper Co., Ltd., West Lothian, Scotland
7. Chollet, J. L., Anglo Paper Products, Ltd., Quebec City, Que.
8. Clark, D. B., Canada Colors & Chemicals, Montreal, Que.
9. De Luca, E., Celgar, Ltd., Vancouver, B. C.
10. Del Valle, F. R., Celulosa de Chihuahua, S.A., Chihuahua, Chih., Mexico
11. Dewhirst, L., Sudbrook Pulp Mill, Ltd., Monmouthshire, England
12. Diaz, H., W. R. Grace & Co., Paramonga, Peru
13. Dick, R. H., Canadian Industries, Ltd., McMasterville, Que.
14. Feiner, J. H., The E. B. Eddy Co., Ottawa, Ont.
15. Forbes, J. A., Hart Products Co. of Canada, Ltd., Toronto, Ont.
16. Galindo, H. L., Celulosa de Chihuahua S.A., Chihuahua, Chih., Mexico
17. Gartner, Degussa Frankfurt, Frankfurt/Main Weipfranenstrig, West Germany
18. Giertz, H. W., Technical University of Norway, Trondheim, Norway
19. Gilbert, D. S., Solvay & Co., Belgium
20. Hagbarth, P. O., OP Hagbarth Engineering, Stockholm, Sweden
21. Hart, J. S., St. Lawrence Corp., Ltd., Montreal, Que.
22. Hartler, N., The Central Lab., Stockholm, Sweden
23. Herbst, J., Industrial Cellulose Research, Ltd., Hawkesbury, Ont.
24. Heyser, E. R., Canadian Industries, Ltd., McMasterville, Que.
25. Howard, E. J., Industrial Cellulose Research, Ltd., Hawkesbury, Ont.
26. Iparraguirre, N., W. R. Grace & Co., Paramonga, Peru
27. James, R. H. W., Columbia Cellulose Co., Ltd., Prince Rupert, B.C.
28. Kerr, W. D., Fraser Co., Ltd., Edmundston, N. B.
29. Kleinert, T. N., Pulp & Paper Res. Inst. of Canada, Montreal, Que.
30. Kuchn, K., Kali Chemie A.G., Hannover, Germany
31. Legg, G. W., Standard Chemical, Ltd., Montreal, Que.
32. Meret, R. G., MacMillan, Bloedel & Powell River Co., Powell River, B. C.
33. Meyer, R., Stadler Hurter International, Ltd., Montreal, Que.
34. Nicholls, G. A., N. Z. Forest Products, Ltd., Private Bag, Auckland, New Zealand
35. Nordstrand, E., Thurso Pulp & Paper Co., Thurso, Que.
36. Paterson, R. M. L., Columbia Cellulose Co., Prince Rupert, B. C.
37. Patrick, K., Fraser Co., Ltd., Edmundston, N. B.
38. Pinder, K. L., Dow Chemical of Canada, Sarnia, Ont.
39. Rapson, W. H., University of Toronto, Toronto, Ont.
40. Richter, A., Hart Products Co. of Canada, Ltd., Toronto, Ont.
41. Richter, R. E., Dow Chemical Co. of Canada, Sarnia, Ont.
42. Robinson, R. A., Celgar, Ltd., Castlegar, B. C.
43. Rys, L. J., Celulosa de Chihuahua, Anauhuac, Chih., Mexico
44. Schenck, M. R., Zellstoffebrnk Waldhof, Mannheim, Germany
45. Schepp, R., Aschaffenburger Zellstoffwerke A.G., Redenfelden, Germany
46. Scribner, H. C., Electric Reduction Co. of Canada, Toronto, Ont.
47. Smith, D., North Western Pulp & Power, Ltd., Hinton, Alb.
48. Smith, J. F., Inveresk Paper Co., Weybridge, Surrey, England
49. Spinner, I. H., U. of T., Toronto, Ont.
50. Standen, R. H., Du Pont of Canada, Ltd., Montreal, Que.
51. Stevens, J., Can. Inter. Paper Co., Montreal, Que.
52. Stocker, F. W., E. B. Eddy Co., Hull, Que.
53. Thierfelder, K., Zellstofffabrik Waldhof, Steinernkreuzweg, Germany
54. Ulmanen, V. H., Rauma Repola oy Finland, Rauma, Finland
55. Wallace, J. D., Dow Chemical of Canada, Ltd., Sarnia, Ont.
56. Wayman, M., Sandwell International, Ltd., Vancouver, B. C.
57. Wilson, J. W., Columbia Cellulose Co., Ltd., Prince Rupert, B. C.

A number of questions were submitted to the several authors which, because of time limitations, were not answered at the conference. Dr. Kraft announced at the end of the conference these questions would be considered by the authors and the answers, together with additional discussion, would be presented at the 1961 Annual Meeting of the Association in February in New York.

A reception for overseas and Canadian visitors to the conference was held on Monday night with some 83 people attending, including members of the Pulp Purification Committee and technical program speakers.

At noon on Tuesday, June 14, the following people were head table guests of the conference and Messrs. Kraft, Doane, McGovern, and Nethercut spoke briefly about various aspects of the conference.

F. Kraft, conference chairman, Pulp Purification Committee Chairman, and moderator, Session I
J. N. MacGovern, Pulp Manufacture Division Chairman
R. J. Auchter, Technical Program chairman and Pulp Purification Committee Vice-Chairman
F. P. Doane, TAPPI Executive Committee Member, Conference Advisor, and Moderator, Session IV
P. E. Nethercut, TAPPI Executive Secretary
J. M. McEwen, TAPPI Executive Committee Member
J. F. Whalen, Technical Program Committee
J. D. Wethern, Technical Program Committee
F. Casciani, Moderator, Session III
R. J. Stevens, Moderator, Session II
H. V. Bialkowsky, Moderator, Session VI
R. P. Whitney, Moderator, Session VII
L. H. Crosby, Moderator, Session V
L. B. Taylor, Secretary, Pulp Purification Committee

1960 TAPPI Pulp Bleaching Conference Registration

1. TAPPI members 200
2. Local Section members (by states):
   - Georgia 1
   - Illinois 2
   - Mississippi 1
   - North Carolina 2
   - New York 1
   - Texas 1
   - Wisconsin 6

   14
3. Nonmembers 87
4. Pulp & paper company registrants: TAPPI members, 99; nonmembers, 42
5. Converter registrants: TAPPI members, 1; nonmembers, 0
6. Allied ind. registrants: TAPPI members, 65; nonmembers, 33
7. Consultant registrants: TAPPI members, 13; nonmembers, 0
8. Univ., inst., govt. registrants: TAPPI members, 9; nonmembers, 5
9. Number of Canadians: TAPPI members, 19; nonmembers, 18
10. Number from other countries: TAPPI members, 13; nonmembers, 7
11. Number of people from which state:

Alabama, 5	Mississippi, 1
Alaska, 1	Minnesota, 8
California, 2	New Hampshire, 2
Colorado, 1	New Jersey, 7
Connecticut, 4	New York, 38
Delaware, 4	North Carolina, 9
Florida, 1	Ohio, 14
Georgia, 4	Oregon, 1
Idaho, 1	Pennsylvania, 10
Illinois, 22	South Carolina, 1
Indiana, 1	Tennessee, 5
Louisiana, 3	Texas, 2
Maine, 6	Virginia, 4
Maryland, 4	Washington, 12
Massachusetts, 3	Wisconsin, 35
Michigan, 19	

A. J. Winchester, TAPPI Technical Secretary
H. O. Teeple, TAPPI Technical Associate

Arrangements have been made for the publication of paper nos. 2, 7, 8, 9, 10, 12, and 14 in the October and November issues of *Tappi*. The panel discussion, "Progress in Pulp Bleaching," under the moderation of R. P. Whitney, The Institute of Paper Chemistry, Appleton, Wis., will also be published at an early date.

The other papers presented at the conference will constitute portions of the new revision of the pulp bleaching monograph scheduled for publication early in 1961, according to Editor-in-Chief W. H. Rapson, University of Toronto, Toronto, Ont.

Thanks are due to the other members of the Pulp Purification Committee, whose names are listed below, for their fine assistance throughout the conference.

Kraft, F., *chairman*, Marathon Corp., Menasha, Wis.
Auchter, R. J., *vice-chairman*, Kimberly Clark Corp., Neenah, Wis.
Taylor, L. B., *secretary*, Columbia Southern Chemical Corp., Pittsburgh, Pa.
Crosby, H. L., The M. W. Kellogg Co., New York, N. Y.
Doane, F. P., Jr., Bergstrom Paper Co., Neenah, Wis.
Ernest, F. M., Allied Chemical & Dye Corp., Syracuse, N. Y.
Fennell, F. L., du Pont de Nemours & Co., Inc., Wilmington, Del.
Harbin, A. D., Diamond Alkali Co., Painesville, Ohio
Hiett, L. A., Buckeye Cotton Oil Co., Memphis, Tenn.
Howard, E. J., Industrial Cellulose Res., Ltd., Hawkesbury, Ont.
Kindron, R. R., Food Machinery & Chemical Corp., Princeton, N. J.
MacGugan, I. C., Wyandotte Chemical Corp., Wyandotte, Mich.
MacLaurin, D. J., MacMillan, Bloedel & Powell River, Ltd., Vancouver, B. C.
Northgraves, W. W., Olin Mathieson Chemical Corp., Baltimore, Md.
Rapson, W. H., University of Toronto, Toronto, Ont.
Rice, W. D., P. H. Glatfelter Co., Spring Grove, Pa.
Robinson, J. M., Champion Paper & Fibre Co., Hamilton, Ohio
Simmonds, F. A., Forest Products Laboratory, Madison, Wis.
Solari, R. J., Shell Chemical Corp., New York, N. Y.
vanGoethem, G. E., Packaging Corp. of America, Filer City, Mich.
Wayman, M., Sanwell International, Ltd., Vancouver, B. C.
Wethern, J. D., Riegel Paper Corp., Acme, N. C.
Whalen, J. F., Combined Locks Paper Co., Combined Locks, Wis.

A modest program was arranged for a number of ladies who came to the conference with their husbands

In passing, it may be of interest to note the use of TAPPI's new keysort conference registration cards facilitated the ascertaining of the following statistical information about the people who attended the conference.

1960

Fall Conferences

of the

Technical Association

of the

Pulp and Paper Industry

Eleventh Testing Conference
Pantlind Hotel, Grand Rapids, Mich.
Sept. 27–29, 1960

Fifth Deinking Conference
Conway Hotel, Appleton, Wis.
Oct. 5–7, 1960

Tenth Corrugated Containers Conference
Royal York Hotel, Toronto, Ont.
Oct. 10–13, 1960

Fifteenth Plastic Plastics-Paper Conference
Syracuse Hotel, Syracuse, N. Y.
Oct. 17–19, 1960

Fifteenth Engineering Conference
Robert Meyer Hotel, Jacksonville, Fla.
Oct. 24–28, 1960

Fundamental Research Conference
Northampton Hotel, Northampton, Mass.
Nov. 3–5, 1960

TAPPI PROFILES

William R. Willets, program chairman of the Eleventh Testing Conference, is Assistant Manager, Technical Service Laboratories, in charge of the paper section, of the Titanium Pigment Corp. (a wholly owned subsidiary of the National Lead Co.). Having joined Titanium Pigment, in 1933, as a chemist in the Paper Development Laboratory, his pioneering work aided greatly in titanium dioxide becoming so widely known in the paper industry as a filler and as a coating pigment. In fact, the first article ever published on the use of titanium pigments in paper in the United States was "Use of Titanium Pigments in the Paper Industry," *Paper Trade J.* 97, No. 10: 28–30 (Sept. 7, 1933). A more detailed report was made at the 1933 Fall Meeting of TAPPI at Appleton, Wis., in September: "The Opacifying of Paper by Means of Titanium Pigments," *Paper Trade J.* 97, No. 12: 35–38 (Sept. 21, 1933). Before this, there had been only brief and occasional references to this subject. His article was also one of the earliest on the use of titanium dioxide as a paper pigment. These were followed rapidly by other articles on the use of titanium pigments in paper and board, on retention, coating, and other subjects. Up till now he has been the author or co-author of over 50 articles on the paper industry and its technology, as well as having contributed various chapters to TAPPI Monographs 7, 19, and 20.

Born in Montclair, N. J., on April 20, 1905, Bill Willets graduated from Montclair High School at the age of 15, and obtained a B.S. in 1926 from the State College of Forestry, Syracuse, N. Y. His first experience in a paper mill was in summer employment in the beater room of the Hamersley Manufacturing Co. in Garfield, N. J. Another summer he was employed by the West Virginia Pulp and Paper Co., in Mechanicville, N. Y.

His first employer after he graduated from college was the Oxford Paper Co., with whom he remained until 1929. As a chemist in the company's research laboratories then located at Bush Terminal, Brooklyn, he worked on pulping, fibers, and fillers. It was here that he first experimented with titanium dioxide. In 1929, as an engineer for Western Electric Co. in Kearny, N. J., he worked on what was then a new development in the communications industry—pulp insulation of conductors for telephone loop cables. His work included studies of pulps and their beating and refining to develop optimum electrical properties while still maintaining requisite strength. In 1930 he presented a paper before the Society of the Chemical Industry at the Chemists' Club in New York City on "Hydrogen Ion Methods in the Paper Industry," *Paper Trade J.* 93, No. 1: 37–41 (July 2, 1931), and while with the Western Electric co-authored several articles on pulp testing. From 1933 to date he has been with Titanium Pigment Corp., where he has always been in charge of the paper laboratory. His work there has contributed greatly to present theories of filler retention, and also to paper coating.

For a period during the war, 1942–1944, he was on loan as a dollar-a-year consultant to the Conservation Division of the War Production Board for Pulp and Paper, and Printing and Publishing. While there, he helped to draft orders on paper conservation, acted on various appeal committees and, in general, cooperated with other WPB and Government Departments on paper usage.

Bill Willets has been a member of TAPPI since 1927. He helped to organize the Metropolitan District of the Empire State Section, which held its first meeting on June 8, 1948, at Fraunces Tavern in New York City, and was its program chairman for three years. In 1951 he became chairman of the Metropolitan District, and in 1955 of the Empire State Section. Since 1956 he has continued on the Executive Committee of the Section. At present he is chairman of the Fillers and Pigment Testing Committee of the Testing Division and of the Pigment Studies Subcommittee of the Coating Committee. He is also a member of the Standards Committee.

In his work for the Association he has been ably partnered by his wife the former Lorain Atkinson, better known as "Tommie." Mrs Willets has attended probably as many meetings as her husband. She has always been on various committees of the Empire State Section meetings at Whiteface Inn, Whiteface, N. Y., and in 1958 she was in charge of Ladies' Activities at the Ninth Coating Conference at Bedford Springs, Pa.

Many other organizations have claimed his services. A member of the American Society for Testing Materials since 1937, he took part in ASTM symposia on Conditioning and Weathering (1952) and on New Developments in Paper Testing (1958). He is past chairman of Committee D-6 on ASTM Committee E-12 on Appearance since 1946, and has been a member of ASTM Committee D-25 on Casein and Similar Protein Materials since the committee was organized in 1956. He is active on numerous subcommittees of each technical committee and was formerly a member of ASTM Committee D-9 on Electrical Insulating Materials. Last June he was elected a Member of the ASTM Board of Directors.

He has been a member of the American Chemical Society since 1926, and a Fellow of the American Institute of Chemists for about 15 years. Secretary-treasurer of the Society of Rheology since 1953, he is also a member of the Governing Board of the American Institute of Physics, as well as a member of both Alpha Chi Sigma and Alpha Xi Sigma. He has lectured on pigments and fillers at the University of Maine and at Lowell Technological Institute. For one semester he conducted an extension course at New York University on pulp and paper. He is listed in "American Men of Science" and in "Chemistry Who's Who."

Among his civic activities are included the duties of a vestryman at St. Ann's Episcopal Church in Brooklyn Heights, where he has lived for more than 27 years.

PERSONAL MENTION

New TAPPI Members

Constantine J. Ballos, Manager, Paper Section, A. E. Staley Mfg. Co., Decatur, Ill., a 1950 graduate of Columbia College.

Ernest H. Barber, Sales Engineer, Combustion Engineering, Inc., Jacksonville, Fla., a 1944 graduate of Kings Point Academy.

Howard A. Benjamin, Administrative Assistant, American Can Co., Barrington, Ill., a 1930 graduate of Michigan State College.

John J. Berilla, Product Development Chemist, Mallinckrodt Chemical Works, St. Louis, Mo., a 1931 graduate of Lafayette College.

Walter F. Biggins, Manager of Technical Services, Ludlow Corp., Needham Heights, Mass., a 1949 graduate of Holy Cross College.

Frederick R. Bliss, Jr., Technical Staff Assistant, Paper Mill, Hammermill Paper Co., Erie, Pa., a 1956 graduate of Gannon College.

Raymond R. Bloom, Chief Industrial Engineer, P. H. Glatfelter Co., Spring Grove, Pa., a 1950 graduate of Pennsylvania State College.

Lawrence G. Brown, Director of Research and Development, Union Bag-Camp Paper Corp., New York, N. Y., a 1952 graduate of Massachusetts Institute of Technology.

Wayne M. Bundy, Director of Laboratories, Georgia Kaolin Co., Elizabeth, N. J., a 1950 graduate of Indiana University, with a Ph.D. degree in 1957.

Robert A. Burns, Industrial Water Consultant, Cyrus Wm. Rice & Co., Pittsburgh, Pa. Attended University of Pittsburgh.

Manuel R. O. Cespedes, Professor, University of Chile, Santiago, Chile, a 1957 graduate of Escuela Forestal De Chile.

William J. Clemens, District Manager, Combustion Engineering, Inc., Jacksonville, Fla., a 1946 graduate of University of Detroit.

Edward D. Collins, Jr., Development Engineer, Albemarle Paper Mfg. Co., Richmond, Va., a 1956 graduate of Virginia Polytechnic Institute.

Carlton W. Dence, Research Associate, Empire State Paper Research Institute, State University of New York, College of Forestry, Syracuse, N. Y., a 1947 graduate of Syracuse University with a Ph.D. degree in 1959 from New York State College of Forestry.

Nils Edholm, President, Esseltewell A.B., Thorsvik, Norrahammar, Sweden, a 1938 graduate of Royal Institute of Technology.

John G. Farrow, Supervisor of Extrusion, Celanese Plastics Co., Newark, N. J., a 1948 graduate of Massachusetts Institute of Technology.

D. Froundjian, Director of Research and Development, Papier und Pape AG, Monheim, Rheinland, W. Germany, a 1934 graduate of University of Berlin with a Ph.D. degree in 1938.

Joseph H. Garst, Engineer, Mobil Oil Co., Kansas City, Mo., a 1942 graduate of University of Colorado.

Orval L. Gerloff, Chemist, Daubert Chemical Co., Chicago, Ill., a 1950 graduate of Loyola University.

Claude Germaine, Manager, La Fibre Française, Rhone, France, a 1943 graduate of Ecole de Lyon.

James P. Hagan, Technical Service Representative, Olin Mathieson Chemical Corp., Baltimore, Md., a 1952 graduate of Villanova College.

Gerald S. Hage, Chief Power Engineer, River Basin Paper Div., Union Bag-Camp Paper Corp., Monroe, Mich. Attended University of Wisconsin.

Douglas H. Hamly, Head of Optical Laboratory, Industrial Cellulose Research, Ltd., Hawkesbury, Ont., a 1928 graduate of University of Toronto.

Donald L. Harbron, Jr., Research Engineer, Black-Clawson Corp., Middletown, Ohio, a 1958 graduate of Western Michigan University.

Donald M. Hartman, Technologist, Shell Chemical Co., New York, N. Y., a 1952 graduate of Georgia Institute of Technology.

Edward A. Hawkins, Superintendent, The Mead Corp., Chillicothe, Ohio, a 1929 graduate of Michigan College.

Carl M. Helm, Laboratory Manager, American Cyanamid Co., Chicago, Ill., a 1950 graduate of Illinois Institute of Technology.

Yrjo Hentola, Head of Research Laboratory, Enso-Gutzeit Oy, Helsinki, Finland, a 1935 graduate of University of Helsinki with a Ph.D. degree in 1946.

John J. Higgins, Chemist, Enjay Laboratories, Linden N. J., a 1955 graduate of Iona College.

Harry F. Hoelzle, Sales Representative, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., a 1941 graduate of Tri-State College.

George R. Hoyer, Project Engineer, Longview Fibre Co., Longview, Wash., a 1957 graduate of College of Puget Sound.

Tamiaki Huzita, Librarian, National Diet Library, Tokyo, Japan.

Scoichi Kimura, Chief Engineer, Tokyo Hoso Yohin K.K., Tokyo, Japan, a 1953 graduate of Tokyo Agriculture University.

John E. Kinsey, Engineer, Western Electric Co., Chicago, Ill., a 1957 graduate of Wabash College.

Karl-Heinz Kleinheyer, Technical Manager, Schleipen u Erkens A.G. & Co., Julich, Germany, a 1954 graduate of Darmstadt Technical University.

Charles T. Law, Sales and Development, Air Reduction Chemical Co., New York, N. Y., a 1954 graduate of Randolph-Macon College.

Roland N. Le Clair, Manager, Pulp Sales, Northeastern Paper Sales, Inc., Chicago, Ill.

Bjor O. Lehto, Senior Project Engineer, Allied Paper Corp., Kalamazoo, Mich., a 1954 graduate of Technical Institute of Finland.

Herbert Lewis, Foreman, A. B. Dick Co., Chicago, Ill.

Mogens Lindholm, Project and Sales Engineer, John W. Bolton & Sons, Lawrence, Mass., a 1949 graduate of Technical University of Denmark.

John A. MacAleese, Assistant Plant Engineer, Newton Falls Paper Mills, Inc., Newton Falls, N. Y., a 1957 graduate of Tri-State College.

James E. Mann, Mechanical Engineer, Bowaters Southern Paper Corp., Calhoun, Tenn., a 1951 graduate of University of Tennessee.

Robert J. Manteufel, Engineer-Supervisor, Eastman Kodak Co., Rochester, N. Y., a 1944 graduate of University of Wisconsin.

George A. Massot, Engineer, Beloit International Corp.,

C.A., Zurich, Switzerland. Graduate of Grenoble University, Paper School.

Raymond A. Mayer, Sales Engineer, Beloit International Corp., C.A., Zurich, Switzerland, a 1950 graduate of Polytechnic Institute de Mons.

Andrew L. McComb, Head Dept. of Watershed Management, University of Arizona, Tucson, Ariz., a 1932 graduate of Pennsylvania State University with a Ph.D. degree in 1934 from Iowa State University.

Gordon D. McNab, President, Alberta West Forest Products Corp., Ltd., Edmonton, Alberta. Attended Western Canada College.

Wilhelm Mohrberg, Laboratory Manager, Heinrich Nicolaus G.m.b.H., Kempten, Germany, a 1947 graduate of Polytechnic Academy with a Ph.D. degree.

Martin Muller, Manager, Technical Service, Sichel-Werke A.G., Hannover-Limmer, Germany, a 1928 graduate of Akademie für Papiertechnik, Kothen.

Paul Nash, President and General Manager, Nash and Harrison, Ltd., Ottawa, Ont., a 1931 graduate of E. T. H. Zurich, Switzerland.

George G. Nelson, Jr., Project Engineer, International Paper Co., Mobile, Ala., a 1952 graduate of Louisiana State University.

Takeo Oshibuchi, Professor, Kochi University, Kochi City, Kochi-Ken, Japan, a 1937 graduate of Kyoto Imperial University, with a Ph.D. degree.

Agamemnon N. Panayotopoulos, Production Manager, E. G. Ladopoulos, Patras, Greece, a 1936 graduate of Ecole Française De Papeterie, Grenoble, France.

Fred R. Paul, Chemist, American Cyanamid Co., Chicago, Ill., a 1960 graduate of Northwestern University, with a Ph.D. degree.

William R. Peterson, Supervisor of Polymer Research, United Rubber & Chemical Co., Baytown, Tex., a 1952 graduate of University of Illinois, with a Ph.D. degree.

Juan B. Pinardi, Sales Engineer, Beloit International Corp., C.A., Zuerich, Switzerland, a 1944 graduate of Turin University.

Donald A. Pohlig, Region Engineer, Paperboard Div., Packaging Corp. of America, Quincy, Ill., a 1956 graduate of Valparaiso University.

Harold A. Price, Manager, Industrial Product, Horkey-Moore Associates, Torrance, Calif.

George H. Rasmussen, Project Engineer, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., a 1954 graduate of University of Wisconsin.

Kyosti V. Sarkanen, Assistant Professor, New York State University, College of Forestry, Syracuse, N. Y., a 1956 graduate of State College of Forestry with a Ph.D. degree.

Walter A. Schuh, Senior Project Engineer, Scott Paper Co., Chester, Pa., a 1954 graduate of Polytechnic College, Munich, Germany.

Theodor Selbach, Engineer, Beloit International Corp., C.A., Zuerich, Switzerland.

Donald L. Smith, Sales Representative, Thwing-Albert Instrument Co., Philadelphia, Pa., a 1951 graduate of Snead (Alabama) College.

John H. Smith, Salesman, Northeast Paper Div., Kelco, Clark, N. J., a 1952 graduate of Rochester Institute of Technology.

James H. Stagie, Project Engineer, Longview Fibre Co., Longview, Wash., a 1959 graduate of University of Washington.

Daniel M. Stewart, Chief Chemist, Polymer Corp., Homebush, N.S.W., Australia, a 1949 graduate of Sydney University.

Ivar H. Stockel, Group Leader, Research & Development Dept., St. Regis Paper Co., East Providence, R. I., a 1950 graduate of Massachusetts Institute of Technology with D.Sc. degree in 1959.

Lawrence O. Strange, Sales Representative, Nopco Chemical Co., Newark, N. J., a 1957 graduate of High Point College.

T. S. Subramanian, Director, Ahmedabad Textile Industry's Research Association, Ahmedabad, India, a graduate of Liverpool University with a Ph.D. and D.Sc. degree.

Bunshichi Takeda, Supervisor, Nihon Geon Co., Tokyo, Japan, a 1954 graduate of Tokyo University with a Ph.D. degree.

Takashi Taniguchi, Chemical Engineer, Kishu Paper Co., Ltd., Osaka, Japan, a 1954 graduate of University of Osaka.

Mahesh C. Varshney, Student, New York State University, College of Forestry, Syracuse, N. Y.

Clarence J. West, Jr., Pulp & Chemical Superintendent, Kimberly Clark Corp., Kimberly, Wis. Attended Virginia Polytechnic Institute and Geo. Washington University.

James R. Wilcox, Technical Sales Representative, C. Withington Co., Inc., Jacksonville, Fla., a 1943 graduate of Iowa State College.

Appointments

George J. Ahlquist, formerly of Western Kraft Corp., is now Chemist for Boise Cascade Kraft Corp., Wallul, Wash.

Dan Ashton, Technical Supervisor for the Crown Zellerbach Corp., has been transferred from St. Helens, Ore., to St. Francisville, La.

Jan I. V. Bergstrom, formerly with the Swedish Forest Products Research Laboratory, is now a Research Engineer for Svenska Cellulosa A/B., Sundsvall, Sweden.

Donald P. Campbell, formerly of Anglo-Canadian Pulp & Paper Mills, Ltd., is now Technical Director for Missisquoi Specialty Board Div., Standard Packaging Corp., Sheldon Springs, Vt.

Angelo Cantoni, formerly of Papelera Rio Parana S. A., is now Mill Manager for Pamer S. A. Mercedes, Uruguay.

Joseph P. Corbin of St. Regis Paper Co. has been transferred from Deferiet, N. Y., to Sartell, Minn., as Mill Manager.

William F. Cyrus of Crown Zellerbach Corp. has been transferred from West Linn, Ore., to St. Helens, Ore., as Technical Supervisor.

Owen T. Dalley, formerly of Champion Paper & Fibre Co., is now Technical Superintendent for Celgar, Ltd., Castlegar, B. C.

James G. Dunlap, Jr., is now Assistant Paper Mill Superintendent of Rhinelander Paper Co., Rhinelander, Wis.

Thomas Gerace of St. Regis Paper Co. has been transferred from Sartell, Minn., to Bucksport, Me., as Resident Manager.

Paul Gora, formerly of Beaco, Ltd., is now Chief Engineer of Kruger Organization, Ltd., Montreal, P. Q.

Robert W. Grott of J. O. Ross Engineering Division has been transferred from Seattle, Wash., to New York, N. Y., as Assistant Chief Engineer of Ross Engineering Div., Midland Ross Corp.

Charles N. Hagar, Jr., is now Plant Manager of Westminster Paper Co., Ltd., Crabtree Mills, P. Q.

Lars A. Hartman of Forans, Ltd., has been transferred from Montreal to Vancouver, B. C., as District Sales Manager.

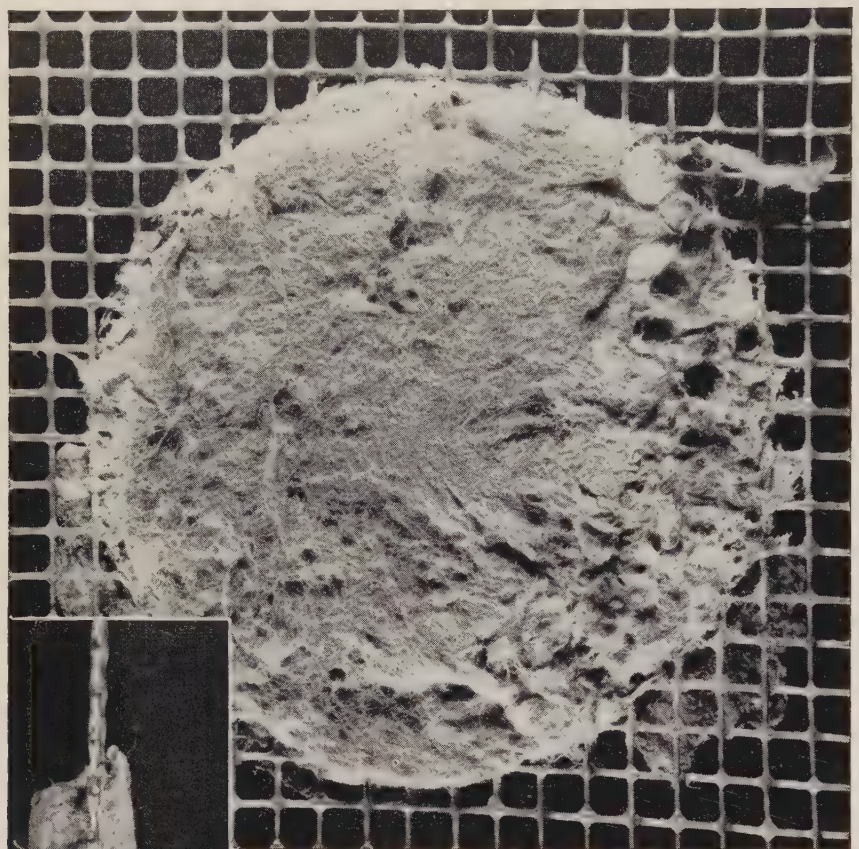
Arthur J. Hang of Scott Paper Co. has been transferred from Everett, Wash., to Chester, Pa., as Manager of Production Services Corporate Staff.

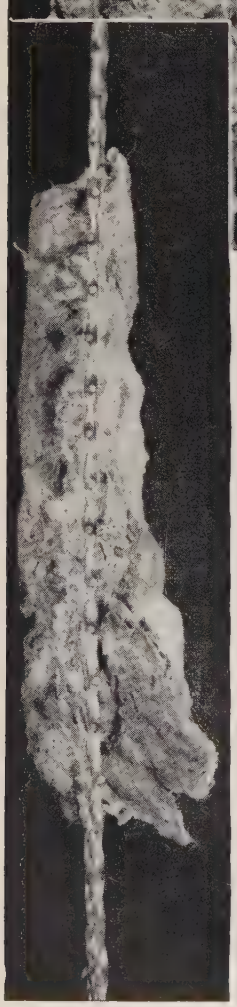
George Heuer of Combustion Engineering, Inc. has been transferred from Chattanooga, Tenn., to Windsor, Conn., as Supervisor of Contract Engineers for Paper Mill Equipment.

George B. Hills, Jr., is now Vice-President of Martin Paper Products Div. of MacMillan Bloedel & Powell River, Ltd., Vancouver, B. C.

Benjamin C. Hoy of St. Regis Paper Co. has been transferred from Hinton, Alberta, Canada to New York, N. Y., as Technical Pulp Sales Representative.

We put a screen on the intake of a Nash Paper Mill Vacuum Pump for a few hours . . .





We were surprised, and so were the Mill Operators, at the fantastic amounts of foreign matter that will pass thru a Nash Vacuum Pump without injuring it, or in any way effecting the operation. Only a Nash Vacuum Pump can do this.

NASH
ENGINEERING COMPANY
South Norwalk, Connecticut, U. S. A.

Milton Jacobs of Chas. T. Main, Inc., Boston, Mass., recently received an honorary doctor of engineering degree from Norwich University.

Elliot S. Kohn, formerly of Rowland Tomkins & Sons, is now a Consulting Engineer in New York, N. Y.

George W. Legg, formerly of Standard Chemical, Ltd., is now Technical Manager for Millspaugh Wimpeg, Ltd., London W. 6, England.

Bernard L. Lenz, formerly student at Oregon State College, is now a Research Chemist for the Forest Products Technical Center of Owens-Illinois Glass Co., Toledo, Ohio.

Ransom S. Meade of American Cyanamid Co. has been transferred from Charlotte, N. C., to Chicago, Ill., as Regional Manager.

William M. Morley, formerly of Elliott Co., is now a Sales Engineer for Stock Equipment Co., Cleveland, Ohio.

William E. Morris, formerly of Allied Chemical Co., is now with the Polychemicals Div. of West Virginia Pulp & Paper Co., Charleston, S. C.

Louis L. Mrachek of the Mead Corp. has been transferred from No. Leominster, Mass., to Brunswick, Ga., as Manager of Services for Brunswick Pulp & Paper Co.

D. Steward Quern of Food Machinery & Chem. Corp., has been transferred from New York, N. Y., to Charlotte, N. C., as Southern Sales Coordinator.

Aaro J. Saarikko is now Maintenance Superintendent for Celgar, Ltd., Castlegar, B. C.

Alfred J. Seaquist, formerly of W. R. Grace & Co., Lima, Peru, is now Assistant Project Manager for the Beloit Iron Works, Beloit, Wis.

Clyde W. Steele of Champion Paper & Fibre Co. has been transferred from Pasadena, Tex., to Hamilton, Ohio, as Technical Advisor.

Harvey K. Waters is now District Manager of Swenson Evaporator Co., Minneapolis, Minn.

Alvin R. Wilson, formerly of Le Pages', is now Product Development Manager for Cel-Fiber Div., Personal Products Corp., Milltown, N. J.

Warner L. Zellner is now Manager of Latin-American Sales for Beloit Iron Works, Beloit, Wis.

INDUSTRY NOTES

North American

Statistics

*Paper and Paperboard Production**

Paper and paperboard production in the first five months of 1960 is estimated at 14,625,000 tons, 4% above the year-earlier total. Production of paper, at 6.6 million tons, was 7½% above the output in the first months of 1959; paperboard production, at 6.7 million tons, was up 2%. Construction paper and board production was 1.3 million tons, 2% below the year-earlier total. Operating rates in June continued at the May levels, indicating an output total for the first half of 1960 at 17.5 million tons. Output at this rate would be 3% above the year-earlier total and would establish a new six-month high for the industry.

*Pulpwood**

Total receipts of pulpwood for January–April, 1960, were 13,612,000 cords, an increase of 1,631,000 cords over receipts for the comparable period last year. Domestic receipts were 1,550,000 cords above the year earlier total, and imports increased 81,000 cords. All of the regions showed increases ranging from 10% in the northeast, to 19% in the north central region.

Pulpwood consumption for January–April, 1960, was 13,495,000 cords, an increase of 819,000 cords over the same period of 1959. All of the regions showed increases ranging from 4% in northeast and south central to 15% in the north central region.

Inventories of pulpwood at the end of April were 5,260,000 cords, a decrease of 146,000 cords below March, 1960, and a 55,000 cord decline from April, 1959. Two regions showed decreases: North central decreased 0.1% and northeast decreased 15%. Three regions showed increases ranging from 3% in the west to 28% in the South Atlantic.

*Wastepaper and Other Fibrous Materials**

April wastepaper receipts were 757,000 tons; for the first four months of this year they totaled 2,995,000 tons, a decrease of 81,000 tons below receipts for last year.

Wastepaper consumption for April was 753,000 tons; the January–April total was 3,026,000 tons, a decrease of 14,000 tons below consumption for the same period last year.

Inventories at the end of April were 557,000 tons, an increase of 4000 tons above March, and an increase of 86,000 tons above inventories at the end of April, 1959.

Consumption of total fibrous materials for April was 830,000 tons; the January–April total was 3,363,000 tons, a decrease of 24,000 tons below consumption for the comparable period last year.

Inventories of total fibrous materials at the end of April were 982,000 tons, 21,000 tons below March and 77,000 tons above inventories at the end of April, 1959.

*Wood Pulp**

Production of wood pulp for January–April, 1960, was 8,419,000 tons, an increase of 516,000 tons above the comparable 1959 total.

Wood pulp consumption in the manufacture of paper and board for January–April, 1960, was 8,691,000 tons, an increase of 511,000 tons above consumption for the same period last year.

Imports of wood pulp for January–April, 1960, were 779,067 tons, a decrease of 2% below imports for last year. Imports from Canada for January–April, 1960, were 657,286 tons, an increase of 2% above the comparable period of 1959. Overseas imports for January–April, 1960, were 114,007 tons as compared to 149,176 tons for the same period last year.

Exports of wood pulp for January–April, 1960, were 283,484 tons, as against 196,643 tons exported during the same period last year.

Inventories of wood pulp at paper and board mills at the end of April were 521,023 tons, a decrease of 17,000 tons below inventories at the end of March and 24,000 tons below inventories at the end of April, 1959.

Fiber Boxes Forecast

Demand for fiber boxes in 1960 will be 4% above 1959 shipments, and during the first half of 1961 fiber boxes are expected to enjoy a 9½% gain over the level of shipments in the first half of 1960, according to Peter W. Hoguet, president of the Econometric Institute.

Mr. Hoguet predicted that in 1960 weekly fiber box demand would average 2197 million sq. ft. as against 1959's level of weekly shipments of 2108 million sq. ft. In 1961, weekly fiber box demand will average 2222 million sq. ft. in the first quarter, 2301 million sq. ft. in the second quarter, and 2317 million sq. ft. in the third quarter.

These forecast gains for fiber boxes were based on the expected increase in end use activity and a gradual pickup in the economy, which will accelerate in 1961, when a considerable rise and boom is expected. Mr. Hoguet said that there was no possibility of a recession in 1961 and that the current quarter is the low point for the next 18 months.

Overseas

Israel

First, Fully Integrated Pulp and Paper Mill Completed

Israel's primary supplier of paper—the American Israeli Paper Mills, Ltd. at Hadera—has now become this young country's first, fully integrated pulp and paper mill, capable of digesting domestic straw and cornstalks and converting them to newsprint, wrapping and fine printing papers, and finished products, such as paper napkins and towels.

As a result of a $12,000,000 expansion program, the American Israeli Paper Mills have doubled annual production capacity, passing the 40,000 ton mark, introduced a new series of paper grades, established Israel's first pulp mill, improved quality control by installing additional electronic equipment and research laboratories, and is constructing its own independent power supply. AIPM assets now total $20,000,000.

The expansion included a complete rebuild of the no. 1 paper machine and construction of a no. 2, 138-in. Beloit. Both are now turning out paper of various specifications, ranging from 30 to 300 g. per sq. m. (12 lb.; 24 × 36-500 to

*American Paper and Pulp Assoc., *Monthly Statistical Summary* 38, No. 7 (July, 1960).

180 lb. 24 × 36-500) including book, bond, kraft and sulfite wrapping, newsprint, manifold, tissue, fruit wrap, duplicating, and offset papers plus a complete line of consumer products.

AIPM was able to utilize local straw and cornstalks to produce over half of its bleached and unbleached pulp requirements only after comprehensive research by Israeli and American scientists and technicians had devised methods to make economical use of the raw materials. The remainder of the needed pulp will continue to be imported. Utilization of the local straw and cornstalks by the new pulp mill is yielding Israeli farmers about $1,000,000 a year. Meanwhile, intensive research is continuing in the search for additional locally grown, pulp yielding materials. Dollar savings to Israel, as a result of the expansion, amounts to $4,000,000 annually, an important development for a country striving to achieve economic self-sufficiency. Furthermore, the pre-expansion staff of some 250 workers has been doubled.

A rising standard of living in Israel has resulted in a rapid increase in the per capita consumption of paper, which has jumped to 61 lb., placing it well ahead of many European and South American countries. Improved marketing methods and growth of supermarkets, greater use of paper by the food and allied industries, are a few of the main reasons for the continuing increase in paper sales in Israel.

Pulp Mill

The pulp mill is based on the soda process, uses a continuous Pandia digestion system and has a potential capacity of 100 tons of bleached pulp per day. In the beginning, the production rate will be 60 tons of pulp; in the future, the capacity can be raised to 100 tons a day with only a relatively small capital investment. The bleach plant has an initial capacity of 100 tons a day. While the cooking, washing and bleaching departments of the pulp mill are of the conventional type, transportation and pretreatment of the straw and cornstalks are rather new and different.

The ricks of straw and cornstalks are built over a system of flumes through which the bales are floated to the pulp mill. The details for this flume system were worked out by the Hydraulics Department of the Haifa Technion Institute, using a mockup. All the flumes, which can be selectively closed down, converge on a central flume ending at the locally constructed pickup conveyor. The water in the flume is effluent water, circulated by a 2500 g.p.m. pump. The dirt in the water is screened out by a traveling dirt screen.

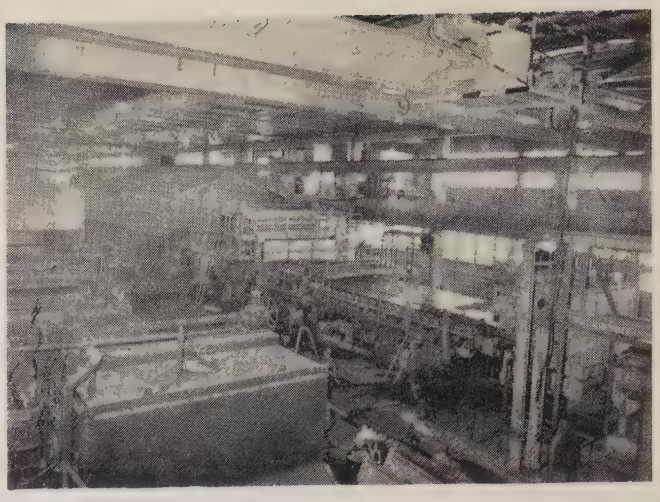
Straw Preparation

Owing to specific conditions in the country, the pulp mill will have to handle a variety of agricultural residues. This imposes a need for flexibility and compromise rarely encountered in other mills which normally have a uniform supply of raw materials. The complicating factor is mainly the cornstalks, which must be depithed before cooking.

Each of the bales, weighing about 100 lb. are freed from their wires and go into three bale breakers, specially designed by Bauer Bros., Springfield, Ohio.

The material, passing through magnetic traps, is fed into three 150 hp. Bauer single disk 36-in. refiners. The purpose of these refiners is to break the cornstalks and free the pith. In the case of straw, the disk refiners' action is relatively gentle and serves to break up the nodes.

After leaving the refiners, the material falls on three 72-in. single shaker screens. In the case of straw, the shakers shake out the dust and debris, but in the case of cornstalks a grading of the raw material is achieved. The screened portion consist of long fibers, while the material falling through the slots consists of pith and small fibers. This fraction can either be sold as cattle feed and chicken litter or can be further processed for recovery of the short-fiber fraction. The fractionation method was worked out at the laboratories of Bauer Bros. The reclaimed fiber fraction is



A partial view of the two paper machines

added to the bulk of the material and cooked, while the pith fraction is thickened, pressed, and used as chicken litter or fuel. The raw material then is washed in a washing silo and pumped on to the Pandia conveyor, which doubles as a drainage conveyor.

Cooking

The Pandia is a four 36-in. tube (with provision for two additional tubes) continuous cooker with blow tank and conventional instrumentation panel. The brown stock is passed through a 36-2 Sprout, Waldron, single rotating disk refiner.

The washed brown stock is screened through three primary Cowan screens and one tailing screen. The final cleaning is done by four 623 Bauer primary Centri•Cleaners and one 622 secondary cleaner. The pulp can either go to a 3% stock chest or to two high density (14%) chest each with a capacity of 150 tons pulp.

Bleaching

The bleaching is done in a conventional three-stage bleaching system, designed by Kamyr. There is one chlorine tower, one caustic tower, and two hypo towers with intermediary washers. All towers and chests are lined with acid-resistant tiles and the metal parts are of 304 type stainless steel. The bleached pulp can be sent directly to the paper machines or to a high density chest.

Instrumentation

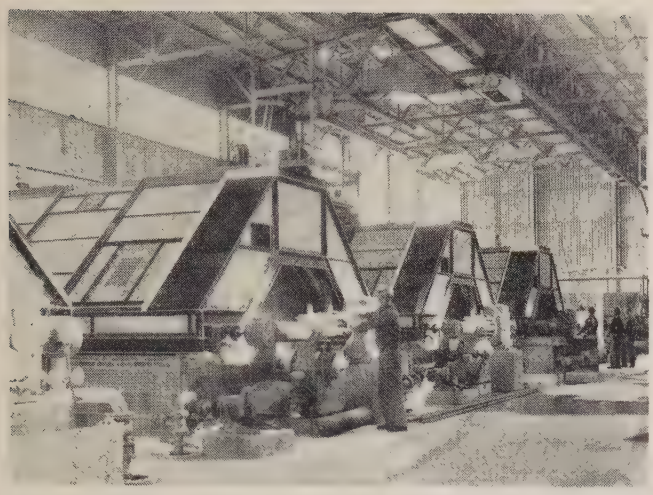
The instrumentation, supplied by Foxboro, is of the most advanced type. The consistency regulators are De Zurick paddle type regulators. The stock flow meters are of the magnetic type. The rotameters are Brooks rotameters. All recorders and indicating instruments are concentrated on several panels so that the operators can see the situation at a glance.

Paper Mill

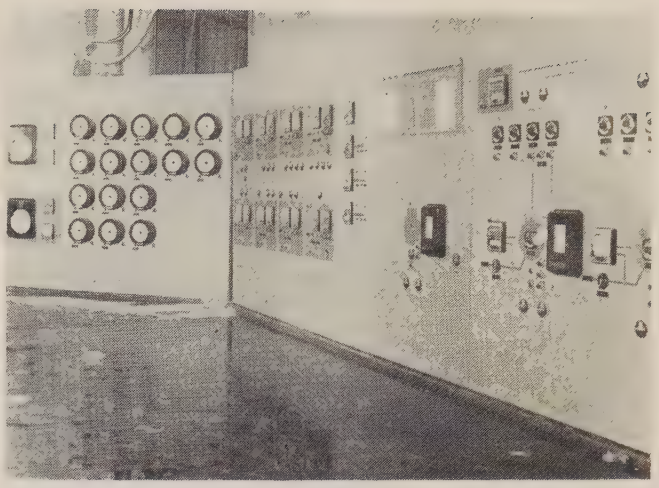
Pulp yard and stock preparation

As the pulp mill covers only 50% of the pulp needs, the rest consists of various dry pulps bought abroad. The bales of dry pulp are kept under a roof and are transported to stock preparation by a Cleveland crane system using screws for picking up three bales at a time (1200 lb.). This crane is used at the same time for stacking the bales as they are unloaded from trucks. The whole operation is controlled by one man sitting in a cabin above the screws.

Stock preparation consists of: three slushing units (one hydrapulper and two Morden slushmakers); seven Morden stockmakers, and eight Claflin refiners as primary and secondary refiners. The stock preparation system is designed for maximum versatility and flexibility; the complete depart-



The washer floor in the new pulp mill of the AIPM at Hadera



Pulp mill preparation at AIPM is carefully controlled. The instrumentation, applied by Foxboro, is of the most advanced type

ment is controlled by a central instrumentation panel which blends and routes the stock to the paper mill.

Each paper machine has three stock chests and a machine chest—which allows for versatile blending. The addition of all chemicals is centrally controlled by the stock preparation operator at the stock preparation instrumentation panel. Further quality and operational control is ensured through the wide usage of consistency regulators and magnetic flowmeters.

Each machine has a machine Jordan (which is controlled by the machine tender). All stock preparation is located in a separate area which minimizes refining water.

Paper machine no. 1

This machine was originally built by Bertrams & Co., Edinburgh, Scotland, and operated from 1953 to the end of 1959, at which time the machine was shut down for approximately 60 days for an extensive rebuild program. Its purpose was to increase the capacity of this machine and to bring about higher quality control in operation. The rebuild included, among other things, the installation of the following new equipment:

Beloit pressure headbox.
13 additional 75-lb., 5-ft. driers.
A new smoothing press.
Replacement of the verticle size press with a horizontal press.
A new condensate system and a new air removal system.
A high-speed Cameron rewinder.
Rebuild of the drive.

The wire of this machine is 136-in. wide and 80 ft. long. The machine operates at speeds up to and including 1200 f.p.m. and has a drying capacity of approximately 120 tons per day. The screening and cleaning section includes:

Three Jonsson screens.
Seven primary Bauer Centri•Cleaners.
Two secondary Dirtec cleaners.

This machine manufactures paper varying in weight from 30 lb. (24 × 36—500) to 180 lb. (24 × 36—500). The grades made on this machine are fine printing and writing papers, kraft and sulfite wrapping papers, kraft multiwall sack paper, newsprint, and wood-containing printing papers.

Paper machine no. 2

This new Beloit machine is a combination machine with 22 5-ft. pre-driers and a 12 ft. Yankee drier. This machine produces MF, MG, and crepe papers. The range of weights on this machine are from 12 lb. (24 × 36—500) to 30 lb. (24 × 36—500). The grades primarily produced on this machine include MF and MG sulfite and kraft wrapping papers, lightweight bond and airmail papers, manifold, fruit wrap, tissue toweling, and toilet paper. This machine operates at speeds up to 1500 f.p.m. The wire is 136 in. wide and 95 ft. long.

The screening is done by one Bird screen, one Jones screen, five Bauer Centri•Cleaners, and two secondary Dirtec cleaners. This machine also has a Cameron type 460 rewinder which operates at speeds up to 5000 f.p.m.

Both machines have centralized systems for headbox additives; in addition to which no. 1 machine has a centralized control for size press and calendar stack additives; no. 2 machine has a centralized control for calendar stack additives.

Converting Department

The converting department includes:

Two sheeters.
Two Cameron rewinders.
One 10 roll supercalender.
Tissue napkin and industrial towel converting equipment.

The sheeted paper department maintains a crew of girls as sorters and inspectors, and the paper that is shipped in the form of reams are either ream-sanded or ream-sealed, according to customer's orders.

Power Plant

Steam is supplied by two Combustion Engineering boilers having a combined capacity of 2500 lb. per hour at a maximum pressure of 650 p.s.i.g. The power plant has an extensive water treatment plant. Electrical power is supplied by a Brown-Boveri extraction turbine having a maximum capacity of 12,500 kwa. As a standby, the company is also connected with the general power grid of the Palestine Electric Corp.

Pulp and Paper Manufacturers and Converters

Bowater Board Co.

The recently completed Bowater Board Co. plant at Catawba, S. C.—the first major hardboard mill in the eastern part of the U. S.—has begun full-scale production of smooth-on-both-sides hardboard.

John G. Robinson, manager of the new mill, in announcing the start of Bowater production in June, said that the new installation has been designed to produce 160 million sq. ft. of board a year, using a newly developed air process. Bowaters has produced both hardboard and insulation board in Europe for European markets for the past 30 years.

Initial production of Bowater Board from Catawba will go to the furniture industry, J. R. Hahn, Bowater Board Sales Manager, explained. The Bowater Board mill is located near the heart of the nation's major furniture-producing area in the Carolinas.

Hardboard at the new plant will be manufactured by an improved dry-felting process on which Bowater is obtaining broad patent coverage. The process utilizes high-velocity air to convey chips and wood fibers that are formed into board and has several important features. One such feature is the mill's board press which is equipped with a simultaneous-closing mechanism that facilitates a faster pressing cycle and produces uniform boards from the bottom to the top of the press. A new time-temperature cycle developed for Bowater Board's humidification process enables boards to be shipped at the desired moisture-content level obtained in manufacturing.

Air-processed board can be made either thinner or thicker than hardboard normally produced by wet process. It can be specifically tailor-made in manufacturing to meet critical field end-uses. The density can be controlled by altering the time-pressure cycle to make board products with physical properties not available in natural woods. The air process used by Bowater in the manufacture of hardboard allows better fiber formation and produces an unfinished board with a pleasing warm wood color and two smooth sides, each with superior finishing characteristics.

The Bowater Board mill has one of the fastest production cycles of any hardboard plant in the world with a daily production capacity of 500,000 sq. ft. of board, and requires some 50,000 cords of hardwood annually, it was explained.

Initially, the mill will employ approximately 100 persons on a three-shift, seven-day week operation. The estimated annual payroll will be $500,000.

Part of the equipment used in the mill was designed by Bowater engineers and was tested during the company's 17-month pilot plant program in Oregon, in 1956–57, the mill manager stated.

The new plant is located off U. S. Highway 21 between Rock Hill and Lancaster, S. C., near Catawba. It is served by the Seaboard and the Southern railroads and is within 30 miles of large truck distribution centers in Charlotte, N. C.

Trial cooking and refining operations at the Catawba mill began in March, 1960. Drying and forming trials began in May, with erection of the press being completed the same month. The initial load of board was manufactured in June.

Engineering and construction supervision of the building project was handled by Bowaters Engineering and Development, Inc., of Calhoun, Tenn. Daniel Construction Co., of Greenville, S. C., was the general contractor. Construction began in November, 1958, and was completed in June, 1960.

The Bowater Process of Hardboard Manufacture

The Bowater process of hardboard manufacture creates a dry fiber that is formed into mats by a unique vacuum-felting operation. Fiber is subsequently pressed into finished boards with improved stability.

Wood procurement. Selected southern hardwood species, such as those used in producing the finest grades of furniture, are used to manufacture Bowater board. However, raw material from which Bowater board is made is not suitable for use as a furniture-dimension stock Bowater officials said.

The majority of the raw material needed at the mill will be obtained from the Piedmont section of North and South Carolina, where an abundance of these hardwood species is available.

Wood acquisition for the plant is handled by Catawba Timber Co., the woods organization of Bowaters Carolina Corp., Catawba, S. C. The wood will be bought in segregated species and most of it delivered by rail to the woodyard of Bowaters Carolina Corp., which also serves the adjacent board mill. Wood cut within short distances of the mill will be delivered to the woodyard by the producers' trucks.

Platform scales capable of handling tractor-trailer pulpwood hauling units are available at the mill.

Wood handling and preparation. Truck wood is unloaded at the Catawba woodyard by a 50-ton crawler-type crane. As the wood is delivered it can be placed on either of two 80 by 1000-ft. hardwood and softwood storage piles or dropped directly into a flume which leads to the debarking drums. Wood delivered by rail can be unloaded onto the piles by a crawler crane or placed directly into the flume by a self-propelled rake.

Water from the nearby Catawba River is circulated through the flume by two 10,000-g.p.m. vertical pumps at the rate of 6 ft. per sec. Grit which has been removed from the logs is collected and conveyed from the flume. Two suspended-type barking drums, each of which measures 12 ft. in diameter and 67½ ft. in length, received the logs from the flume. Three 75-hp. induction motors drive each drum through fluid couplings and parallel shaft reducers to removed the bark from the logs.

Bark from the drums is conveyed through a swing hammer shredder to a 14,000-cu. ft. capacity circular bin and then to the combination boiler for fuel. Logs from the drums pass over a series of conveyers to a 66-in. wide sorting belt.

Accepted logs are fed into two 112-in., 10-knife chippers for the initial chipping of the raw material. Blower housings on the chippers discharge the chips into cyclones from which they travel by belt conveyer to a series of screens. Fines from the screens are conveyed to the drum refuse system and oversize chips from the screens are fed into a 36-in. six-knife rechipper.

A high-pressure pneumatic conveying system carries accepted chips from the screens to either of two 200-cord tile silos. Chips are stored here until they are needed for cooking and refining before they are formed into Bowater board.

Rotary plate feeders, each measuring 17 ft. in diameter, remove the chips from the the storage silos. Operating on a variable hourly capacity, the feeders carry the chips to a bucket elevator which empties into an elevated chip surge bin. Plate magnets located in the chute leading to the surge bin remove tramp iron that may have been left in the chips.

Cooking. Chips are withdrawn from the surge bin by the cooker feed screw. The screw is equipped with a variable speed drive which permits the setting of a constant flow rate that coincides with the retention time of chips inside the cooker. Chips remain in the cooker approximately five minutes, regulated by the speed of the paddle-type agitator.

Cooking or, more accurately, steaming of the chips is accomplished by working steam pressure inside the cooker up to 150 p.s.i.

The chips are discharged from the cooker through a rotary valve into a distribution screw. Steam discharge with the chips is vented into the atmosphere.

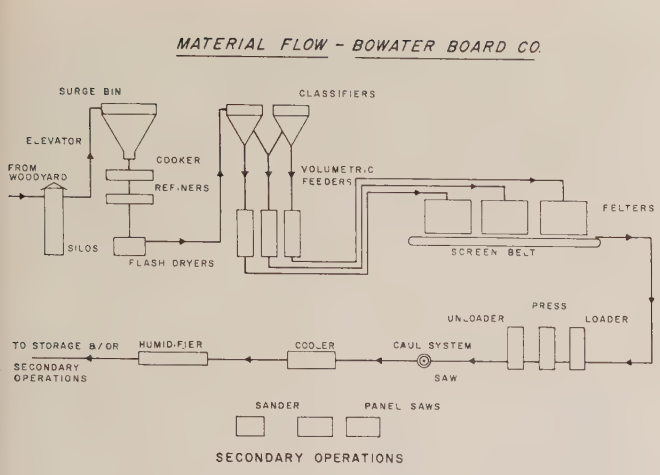
Refining. Four metering screws, one for each of the double-disk refiners, draw cooked chips from the distribution screw. Provision is made to recirculate a slight overfeed of chips in the distribution screw back to the chip surge bin.

The chips pass over plate magnets before entering the twin-screw feeder of each of the four counter-rotating disk refiners. Each refiner has two 400-hp. synchronous motors, each motor driving one disk. The chips are reduced into wood fiber by the action of these disks. The fiber can be mixed with various types of resins as it is being refined. The resins are added into the center of the refiner disks through a hollow motor shaft.

A liquid phenolic resin binder is used for standard grade board. Special tempering resins can be added at this same point to develop a through-tempered board with improved physical properties.

Drying and classifying. Heated air swept through the refiner case conveys the fiber into high-temperature flash-drying equipment. The moisture in the wood and the water added with the resin evaporate rapidly while the fiber is being conveyed.

Two flash driers are in use, equipped with direct-fired (natural gas) air heaters. Each drier is fed by two refiners and in turn discharges the dried fiber into mechanical air separators for classifying.



The fine fraction of fiber from both classifiers is collected in a single combination storage and metering machine called a volumetric feeder. The coarse fraction from each classifier is collected in separate coarse-fiber volumetric feeders. These volumetric feeders are electrically regulated to allow the dispersal of fibers in the proper ratio to produce the exact requirements of Bowater Board.

For startup purposes, fiber can be shunted to waste immediately after leaving the driers to prevent partially ground or wet fiber from entering the volumetric feeders.

Felting. Five metered streams of fiber, each pneumatically conveyed through a separate oscillating nozzle, are felted continuously into the desired mat width and thickness. There are two coarse-fiber streams from each coarse-fiber volumetric feeder and a single fine-fiber stream.

These fiber streams are deposited on a moving wire screen that travels over suction boxes located below the nozzles. A continuous multilayer fiber mat is built up as the screen passes through each section of the felting operation.

There are four such sections or felting areas. The mat is leveled by three shave-off rolls after it has passed through the first three felters. In the fourth felting area, a layer of "fines" is added to the mat, allowing the formation of a finished board with superior surface characteristics.

These numerous thin layers of thoroughly tempered fibers, plus the action of the shave-off rolls during felting, produce a mat with great uniformity and high internal bond strengths.

Pressing. The felted mat now passes through a precompressing area. Here heavy roll-nip pressures consolidate the mat. Next the consolidated mat is edge-trimmed and sawed into required lengths. These mat lengths are deposited on steel cauls and accumulated in a press charger until a full press load of 20 has been stored.

The charger pushes the new load of cauls and mats into the press as the unloader simultaneously withdraws pressed hardboard and cauls from the opposite side.

A total of 475 connected horsepower drives the hydraulic pumps of the press, exerting a pressure of 5270 tons. Mats are held at pressures up to 1000 p.s.i. Steam pressure up to 850 p.s.i. inside the steam plates maintains the temperature from 1 to 2 min. During this period, the combination of heat and pressure evaporates the moisture, increases the density, and polymerizes the phenolic resin binder.

Pressed boards are separated from their steel cauls one at a time as both are removed from the press unloader. The cauls are automatically recirculated to receive another mat and the boards are conveyed through trim saws into the cooler.

An important feature of the Bowater press is its simultaneous-closing mechanism which shuts the openings of the press faster and produces uniform boards from the bottom to the top of the press. This simultaneous closing eliminates the tendency of older presses to create a difference in the time-pressure cycle between the top and bottom boards which often affects the specific gravity of the product and causes a wider variance in its physical properties.

At this point the actual formation of board is complete and all that remains of the Bowater process is final humidifying, sawing, and sanding of the product to meet various customer specifications.

Humidifying, sawing and sanding. After cooling, the boards are immersed in circulating water inside the humidifying vats. The time-temperature cycle for this humidification process, developed during Bowater's pilot plant program, effectively brings Bowater board to the proper moisture-content level for the particular end use.

Boards are stored and subsequently sawed to sizes required as they pass through a panel saw. The product can be ripped and/or cross-cut to individual customer's specifications.

To meet customer caliper requirements, the board, moving at 90 linear feet per minute, is sanded with a three-belt sander. This high-speed sander holds to a caliper tolerance of ± 0.005 in.

Storage and shipping. Bowater board is steel strapped and stored flat in rough trimmed dimensions on pallets. Ample storage space has been provided to permit a proper inventory control of the product line as well as appropriate shipments from inventory to the various market factors.

Shipments from the mill can be made by rail, flatbed truck, or customer pickup. Eight double-door box cars can be loaded from the interior railroad siding and facilities are available to load flatbed trucks inside the plant. Forklift trucks with a 5000 lb. capacity handle all materials mechanically.

The Bowater Board Co. Plant

The new plant building covers 100,000 sq. ft. Its unique design, incorporating an extensive use of concrete construction, minimizes the area where airborne waste fiber might collect and reduces fire hazard considerably, the mill officials explained.

Construction details. The outside walls of the mill building are 10 in. thick and consist of two rows of brick with a 2-in. cavity between them. The walls are supported by concrete grade beams.

The roof of the mill building is in five bays, three with a 60-ft. span and two with a 45-ft. span. Roof slabs of double-T, prestressed structural concrete, covered with builtup tar and gravel, are supported by prestressed concrete beams. Thirty-foot, precast concrete columns, supported by concrete spread footings, support the beams.

A 350-ft. railroad track borders the mill floor for the full length of the interior north wall of the building. Rail cars, therefore, can be easily loaded directly from the storage area. Electrically operated rollup doors cover the track entrances at both ends of the building.

A completely level, 6-in. concrete slab floor, elevated 5 ft. above the outside grade, covers the entire area inside the building. The structural steel fiber-preparation area, which contains the cooking and refining installations, has four floor levels and is located directly adjoining the extreme southeast corner of the mill building.

Two motor-control centers with structural steel frames house the mill's electrical power control panels. One adjoins the fiber-preparation area and the other adjoins the board-forming line.

A two-floor office and shop area containing rest room facilities is located inside the mill building.

Paved truck-access areas and two sloping concrete entry ramps are located outside the building. On the east side is a combined inbound ramp and truck-loading dock, and an outbound ramp, equipped with two vehicle doors, is on the west side.

Electrical system. Electrical power for the mill is obtained from the distribution system of the sulfate pulp mill of Bowaters Carolina Corp. at the same mill site. Maximum power consumption at the Board Co. plant is 5000 kw. Utilization voltages are 2300 v. for motors of 200 hp. and

larger, 440 v. for smaller motors and 120 v. for the lighting distribution system.

All load-center substations are outdoor type. The 1000-kva. substation's low-voltage switchgear and motor-control equipment are installed in ventilated pressurized control rooms. The hardboard machine is driven by a multiple-generator, d.c., adjustable-voltage electrical drive.

The mill wiring system is made up of polyvinyl chloride-jacketed, aluminum-interlocked armored cable installed on aluminum ladder-type racks. The lines for the 13,800-v. feeders are varnish-cambric insulated, three-conductor cables; 2300- and 440-v. feeders are butyl-rubber insulated multi-conductor cables.

The lighting systems are fed separately from departmental load-center substations. The lighting-utilization voltage level is reached by stepdown, dry-type transformers. Mercury vapor fixtures, color-corrected, are used in the manufacturing area of the main process building. Inspection areas in the main process building are equipped with mercury, noncolor-corrected fixtures. Incandescent fixtures are used in all other areas.

Ventilation. A total of 33 air systems utilizing 36 fan motors are in operation inside the mill to provide necessary process and building ventilation.

The Bowater hardboard-manufacturing process uses 90% of the plant's ventilation equipment. Wood fiber used in the formation of Bowater Board is conveyed throughout the system by high-velocity air, moving through ducts which vary in diameter from 4 in. to 3 ft. Air-generating fans have motor sizes varying from 1 to 125 hp. These air systems convey and dry wood fiber and cool finished hardboard sheets.

A low-pressure air system, equipped with industrial-type fans, collects board trimming and sawing waste and conveys it to the waste-storage bin located outside the mill. Five heating-ventilation units, located on the north wall of the mill, supply 202,000 cu. ft. per min. outside air for the inside of the building to compensate for air being exhausted by the manufacturing process. Adjustable louvres located in the south wall of the building can be opened to allow fresh air to enter the plant.

Product Line and Markets

Bowater board products will range from low-density to high-density boards, officials at the new plant announced. The maximum press size is approximately 4 by 16 ft. Bowater board will range in caliper from $^3/_{32}$ to $^3/_8$ in.

The lower-density boards are designed to fit furniture requirements where hardboard must be of sufficiently low density to permit stapling or nailing and for end uses where die-cutting or punching is required.

The higher-density boards with a fine-fiber surface offer superior finishing characteristics to the industrial customer. These boards, produced with high internal bond strength and excellent fiber formation, will be ideally suited for use as cores for decorative laminates, it was explained.

Initial marketing of Bowater board will be to the furniture industry in the southeast, although the company expects to expand the marketing of its product to other industrial users as soon as practicable, Mr. Hahn disclosed.

Included are the home-building and light-construction industries, where hardboard is used as lap and panel sidings, interior paneling, wainscoting, underlayment, etc. Expansion into the building-material market is forecast.

Bowater Board Officials

Mr. Robinson has been with Bowater since March, 1957, serving at the company's pilot plant project in Oregon prior to being named mill manager of Bowater board. Previously he was associated with the Weyerhaeuser Co. as a project engineer, then as superintendent of that firm's hardboard mill in Klamath Falls, Ore. He is an engineering graduate of the University of Minnesota.

Before joining Bowater board in May, 1959, Mr. Hahn had been associated with the sales staff of the Masonite Corp., Chicago, Ill., for 12 years. He also formerly held positions in the sales department of Armstrong Cork Co. He is an engineering graduate of Purdue University, Lafayette, Ind.

Palmer L. Kvale is mill superintendent of Bowater board. A native of Minnesota and a graduate of the University of Minnesota, he was with a mill in Oregon before joining Bowater in February, 1960.

Continental Can Co.

New Fiber Drum Plant in Carteret, N. J.

A new fiber drum manufacturing plant has been opened by Continental Can in Carteret, N. J., where it will produce two kinds of fiber drums for dry products.

The 200,000-sq. ft. plant has been under construction since early 1959 and is the seventh fiber drum installation for Continental Can, which is the nation's principal manufacturer of this package.

Appointments

Roger Geartz has been promoted to manager of Continental's corrugated box plant in Cleveland, Ohio. He replaces F. W. Locke, who has resigned.

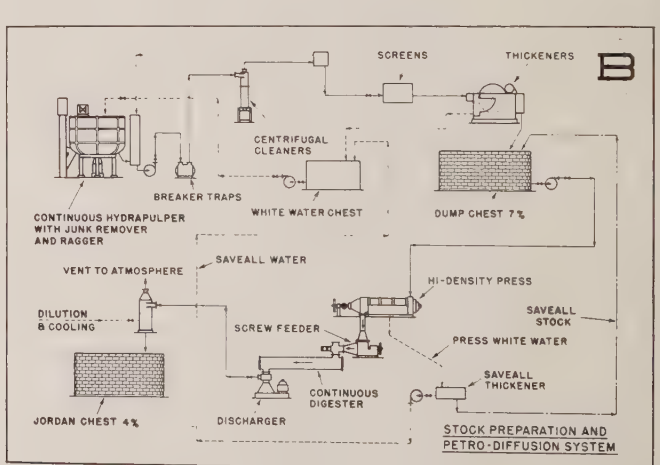
Joseph W. Gary has been named manager of Continental's corrugated box plant in Tyler, Tex. He has been with the company and the premerger Robert Gair Co. for nine years, and has been superintendent at Tyler since the plant began operation in 1958.

Edgar O. Olsen, Jr., has been appointed corrugated box district sales manager in Tyler. For the past eight years, he has been a corrugated box salesman working out of the firm's New Orleans' office.

Elk Paper Mfg. Co.

Petro-Diffusion System Eliminates Asphalt Problem

A new system of equipment to improve the cleaning of waste corrugated stocks is now operating in the mill of Elk Paper in Childs, Md. Designed especially to disperse asphalt and various thermoplastic materials present in waste furnish, the system has successfully upgraded the appearance of the 0.009 corrugating board which Elk manufactures for the packaging industry and has greatly reduced the frequency of shutdowns for cleaning paper machine wires and felts.



Flow diagram of the Petro-Diffusion system as installed at the Elk Paper Mfg. Co.

Known as the Petro-Diffusion system, the new installation combines mechanical cleaning and continuous heating equipment manufactured and supplied as a complete unit by Black-Clawson, Shartle Division, Middletown, Ohio.

To achieve effective dispersion, the P-D system employs a two-phase treatment. The mechanical cleaning phase pro-

duces uniform stock with the asphalt particles well distributed. Subsequent heating of the stock under pressure in a modified Pandia continuous pulping system then melts the particles to the point where the oils and tars are partially vaporized and the remaining carbonized sediment becomes thoroughly diffused in the fibers.

Flambeau Paper Co.

Soil Filtration of Spent Sulfite Liquor

To boost dissolved oxygens in the Flambeau River, Flambeau Paper Co. announced it was stepping up by more than 50% the active treatment capacity of its land area in use for horizontal soil filtration of spent sulfite liquor. Bulldozers and grading machinery are working-over 50 acres to terrace these as a major addition to 80+ acres already in active service. The addition will be fully operative by the time that adverse weather can be expected, according to Leonard Kuehl, company vice-president.

High, gently sloping wasteland is the treatment area, and the 50-acre addition was designed to match the older area that has proved so successful. Spent sulfite liquor is hauled by tank trucks to a station above a series of shallow, relatively level ditches and ponds. Regrading is now intended to decrease quantities of liquor retained above ground and thus make it less likely that any could wash into the stream.

In the treatment area, the liquor seeps horizontally from each ditch to the next lower, and so on. Several hundred yards short of the river the last trace of liquor disappears and no residue can be detected in the stream.

Georgia-Pacific Paper Co.

Black-Clawson Kraft Machine Startup

Georgia-Pacific, Toledo, Ore., reports the beginning of operation of a new Black-Clawson kraft paper machine, which is producing 200 tons per day of bag paper.

The machine is a Hydroflyte cantilever fourdrinier, 175 in. wide, built by the Paper Machine Division of Black-Clawson, Watertown, N. Y. It is equipped with two suction presses, breaker stack, size press, fifty-eight 60-in. driers, and one 8-roll calender stack of open-side design.

Kimberly-Clark Corp.

Noble Wins Rochester Institute of Technology Award

Carl E. Noble of K-C. has been named the 1960 winner of the annual Rochester Institute of Technology award for "outstanding contributions in statistical quality control for the graphic industries."

Dr. Noble was selected for the award by the 20-member planning committee of the Institute's Extended Services Division. He has served as chairman of the Graphic Arts Committee and the Administrative Applications Divisions of the American Society for Quality Control and the Statistical Committee of the TAPPI. He has numerous publications covering the theory and application of statistical methods to the Graphic Arts Industry and is a member of the editorial board of the *Industrial Quality Control* magazine. He has lectured extensively in the United States and Canada, and last October gave a series of lectures in Italy on the application of statistical methods to the Graphic Arts Industry.

He has been associated with Kimberly-Clark since 1946, and has been manager of market planning and research, Consumer Products Division, since 1958.

Carl E. Noble (right) receives engraved silver bowl from Harold W. Kentner, director of extended services, Rochester Institute of Technology

Marinette Paper Co.

Large Wood Screenings Reworked

A ton a day of forest-origin materials formerly lost into the Menominee River at the sulfite pulp mill of Marinette Paper Co. is now kept out of the stream and reworked into useful form by equipment newly installed for this purpose, according to D. J. Dughie, company vice-president.

When newly made sulfite pulp is screened and cleaned, some pulpwood bits are always found which failed to break down completely enough in the cooking to release their cellulose fiber for use in fine tissues. Part of these screenings at the Marinette mill were previously removed and shipped to manufacturers of rougher types of paper, but in spite of normal precautions considerable quantities escaped into the river.

The new system intercepts practically all of the large wood screenings and passes these into a "refiner" for grinding into smaller bits of fiber. This ground-up material is then rescreened. The fine fibers go into the finished pulp, coarser bits return for another trip through the refiner.

Marathon A Division of American Can Co.

Water Pollution Improvement

State pollution officials recently previewed a million dollars' worth of new installations completed this year by Marathon to improve water conditions in the Fox River, East River, and Green Bay.

According to John E. Goode, plant manager, Marathon's northern mill now is processing all of its used water before release to the Fox River. This includes withholding from the stream all spent sulfite liquor that can be collected and making it into useful by-products. Nothing is being discharged into the East River either.

Most recent additions to the company's stream improvement program are a spray drier for turning sulfite liquor into powder and an elaborate system that collects all of the mill's used water for clarifying in huge settling basins before discharge to the Fox River.

In the new spray drier sulfite liquor, already evaporated to syrup form, is atomized as mist into the top of a four-story cylinder. Here it meets an up blast of superheated air that instantly dries it to a fine powder. Mechanical devices separate this powder from the swirling air and steam and it is conveyed away to be bagged for shipment.

A feature of this plant is that it includes equipment for chemically modifying the concentrated liquor before drying. According to Goode, the company has chosen to solve its sulfite pollution problem by converting spent sulfite solids into enough different useful forms so that other industries will take all that the mill produces and at prices that will pay as much as possible of the processing cost. The spent liquor is thus "tailored" to the customer's individual specification, whether he wants it for tanning leather or drilling oil wells or any other purpose.

Marathon's new used water unit starts with pipelines intercepting all mill outfalls, which previously led to the East

River. This effluent now is pumped through a 36-in. pipeline, 5000 ft. long, to a tract of land a mile downstream. Here two settling basins, 100 × 600 × 12 ft. deep, have been constructed to receive the effluent. They hold it long enough for all fibrous and other suspended solids to settle out. The clarified water overflows the basin at the far end and enters the Fox River near its mouth.

Paterson Parchment Paper Co.

High Wet-Strength Paper for Photo Processing Machines

Specialized paper developed for use as leader paper in automatic photographic processing machines has been introduced by Paterson Parchment, Bristol, Pa.

According to Mrs. Herbert W. Mason, director of the Company's Custom Made Paper Department, Photographic Leader Paper Code 557 possesses the extremely high wet strength required to withstand prolonged submersion in water and photograph chemicals. The wet strength is rated at approximately 17 lb. per in., machine direction.

The paper was made for use in the Eastman continuous processor, a device that prints snapshots in an uninterrupted development-washing-fixing processing series.

Samples and additional product information on Code 557, as well as other custom made papers, may be obtained from the Paterson Parchment Paper Co., Bristol, Pa.

Rhinelander Paper Co.

Promotions

George Sutton has been appointed senior assistant paper mill superintendent, and James Dunlap assistant paper mill superintendent; both will work under the direction of Leonard Parkinson, the paper mill superintendent.

Richard Rasmussen, who has been assistant to the director of industrial relations since 1955, was promoted to personnel manager and will continue to report to the director of industrial relations, L. J. McNamara.

Elton T. Krogel assumed the duties of assistant pulp mill superintendent of the company.

Riegel Paper Corp.

Lassiter Corp. to Merge with Riegel

An agreement proposing the merger of the Lassiter Corp. into Riegel Paper Corp. has been signed by the boards of directors of the two companies.

Riegel is a leading producer of flexible packaging materials, bleached paperboard, pulp, folding cartons, and specialty papers. Lassiter, of Charlotte, N. C., is the largest independent converter of packaging films, specializing in the soft goods field. They also manufacture folding cartons, labels, and laminates for many industrial applications.

St. Joe Paper Co.

Columbia Container Facilities Acquired

The facilities of Columbia Container Corp. of Baltimore, Md., and an affiliate company, the Columbia Container Corp. of Virginia, have been acquired by the St. Joe Paper Co. of Jacksonville, Fla.

The two operations bring to 11 the total number of plants operated by the St. Joe Paper Co. Other operations are in Birmingham, Ala.; Cincinnati, Ohio; Hartford City, Ind.; Houston, Tex.; Memphis, Tenn.; Pittsburgh, Pa.; Port St. Joe, Fla.; Rochester, N. Y., and South Hackensack, N. J.

St. Regis Paper Co.

Three-Million Dollar Technical Center

A three-million dollar Technical Center will be built by St. Regis to implement continuing programs of diversification and growth, and to intensify the exploration of new fields of paper, plastics, packaging, and forest products.

Construction of the new Technical Center is scheduled to begin late this year at Clarkstown, N. Y. It will be located on a 60-acre site and its area of 60,000 sq. ft. will comprise offices, laboratories, a technical library, cafeteria, and supporting services. It will accommodate about 180 persons. In addition to the research and development department, technical services and control and technical planning departments will be located at the Center. Programs to be undertaken will relate to materials utilization, printing papers; kraft pulp, paper, and board; bags, packaging, plastics, and other products.

Polystyrene Foam and Paper

A new development in paper and plastic combinations is St. Regis' patented material (U. S. patent no. 2,917,217) in which a flexible sheet of foam styrene is bonded to a flexible sheet of paper or other material.

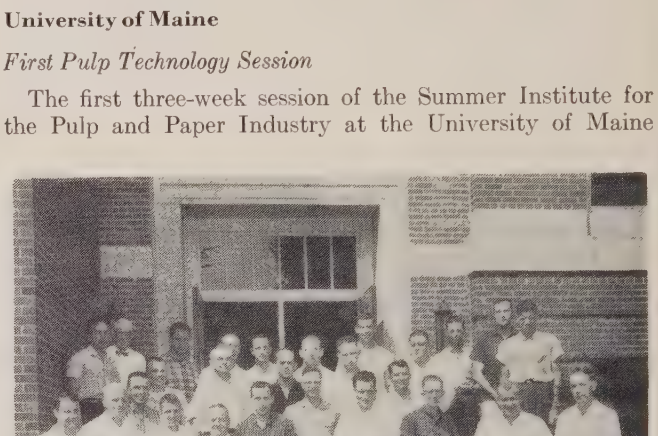
This inexpensive combination of polystyrene foam and paper (or other materials) provides a material which is waterproof, greaseproof, has a high thermal insulation factor, is chemically inert and nonabrasive.

Educational Institutions

University of Maine

First Pulp Technology Session

The first three-week session of the Summer Institute for the Pulp and Paper Industry at the University of Maine



Attending the first three-week session of the Summer Institute for the pulp and paper industry at the University of Maine are, front row, left to right: C. P. Elmore, Babcock & Wilcox Co.; C. H. Anderson, Chas. T. Main, Inc.; Frank Rawlins, U. of M.; Prof. Lyle C. Jenness, U. of M.; D. V. Walden, New York and Pennsylvania Co.; Lewis Bartlett, International Paper Co.; Pieter Van Beek, West Virginia Pulp and Paper Co.; T. F. Clark, Res. & Dev. Division, U. S. Dept. of Agriculture; Harry Carroll, American Potash & Chemical Corp.; A. J. Chase, U. of M.; Second row, left to right: W. E. Hilfrank, S. D. Warren Co.; F. J. Krasofski, Great Northern Paper Co.; N. E. Wendt, American Potash & Chemical Corp.; R. L. Mitchell, North Carolina Pulp Co.; Louis Rotar, Great Northern Paper Co.; Michael Kouris, TAPPI; Third row, left to right: Kenneth Thatcher, International Paper Co.; J. A. Gannett, U. of M.; C. A. Babb, Knox Woolen Co.; H. W. Fowler, Penobscot Chemical Fibre Co.; T. L. Calhoun, New York and Pennsylvania Co.; R. H. Bernstein, Chas. T. Main, Inc.; P. C. Holliday, Jr., Shell Chemical Co.; J. F. McCoy, Finch Pruyn & Co.; J. F. Gorham, U. of M.; J. R. Santoro, Newport Industries Co.; Gary L. Burroway, Columbia Southern Chemical Corp.

ended July 29. Twenty-two men representing 17 companies and organizations registered.

The Institute program, which is sponsored by the university and by the University of Maine Pulp and Paper Foundation, dealt with pulp technology and all phases of pulp manufacture and testing, and is offered primarily to broaden the technical and management training of key personnel in the industry.

N. C. State College

School of Forestry Scholarships

The Scholarship Committee of the Pulp and Paper Foundation, Inc., has awarded scholarships totaling $32,500 in the School of Forestry at North Carolina State College for the 1960–61 academic year.

Announcement of the committee's action was made recently by Dr. R. J. Preston, dean of the college's School of Forestry, and Prof. R. G. Hitchings, faculty member of the Pulp and Paper Technology curriculum in the School of Forestry.

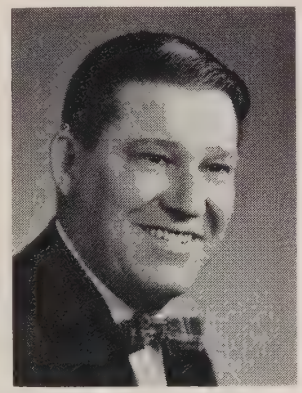
Attending the committee meeting were Dr. H. Y. Charbonnier, chairman, Union Bag-Camp Corp.; Lee Darby, North Carolina Pulp Co.; Harry Cotton, International Paper Co.; and H. D. Cook, Dr. Kingston Johns, Dr. Preston, and Professor Hitchings, all of State College.

Industry Suppliers

Albany Felt Co.

Appointment

Wayne P. Harwood has been appointed a sales engineer in the sales territory covering eastern New York and part of Connecticut.



Wayne Hardwood

General Chemicals Division

Appointment

William E. Houghton has been appointed a sales manager for basic industrial chemicals produced by Allied Chemical's General Chemical Division.

Mr. Houghton, with the division 27 years, will be responsible for sales of aluminum sulfate, aluminum chloride, and aluminum nitrate solutions, ammonium, and potash "alum," a variety of sodium compounds and phosphoric acid.

Babcock & Wilcox Co.

Appointments

R. P. Stuntz has been named manager of field sales and L. D. Christie, Jr., product manager, technical sales, of B & W Refractories Division.

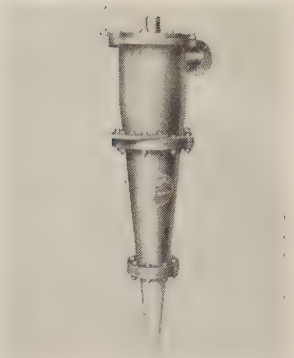
Mr. Stuntz will assume direction of the division's district sales personnel, agents, distributors, and dealers, and Mr. Christie will program and direct field testing and evaluation of new products and provide technical services to field sales personnel.

Bauer Bros. Co.

The Centri-Cleaner "No. 609-9"

A new size Centri-Cleaner, the "No. 609-9," with a capacity of 180 g.p.m., has been announced by Bauer, Springfield, Ohio. Head diameter of the unit is 9 in.

The No. 609 is a highly economical and practical pulp cleaner designed for use on machines making high grade papers such as top quality ledger, bond, and offset.



It is also recommended in the secondary and tertiary stages of No. 620 installations where volume is correct. Pressure drop across the cleaner is 50 p.s.i.

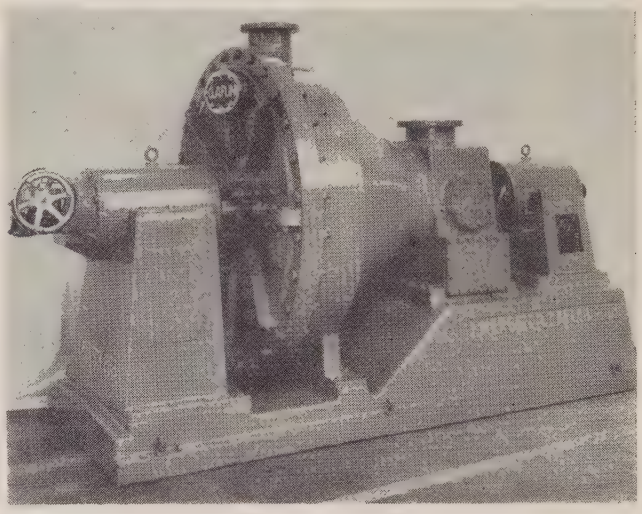
Efficiency of the new cleaner falls between the smaller No. 606 and the larger No. 622. Even though capacity of the unit is double that of the No. 606 and just slightly under that of the No. 622, the new cleaner is "competitive" in price with the smaller No. 606, according to a company spokesman.

John W. Bolton & Sons, Inc.
The Emerson Mfg. Co. Div.

New Model Claflin 202

A new model conical refiner, the Claflin 202, is released to the market by its manufacturer, The Emerson Manufacturing Co. Incorporating all the advanced design features of the Emerson Claflin 303, introduced one year ago, the 202 model provides refining efficiency on all types of furnish exactly equal to that of the 303 model, according to company officials.

Size is the only difference in the two models. The Claflin



The Claflin 202

202 is designed for those mills having need for a refiner of smaller capacity, between 15 and 75 tons per 24 hr. While lighter in weight and dimensionally smaller than the model 303, the model 202 is equal to the larger unit in ruggedness of construction, it being designed to withstand operating pressure of 100 p.s.i.

Bolton Award Essays

Robert A. Bagg, manager of Strathmore Paper Co.'s educational mill visit program at West Springfield, Mass., won first prize of $1000 for his essay in the 13th annual Bolton Award contest on the subject, "Through the Grapevine."

During ceremonies held at the mill, A. L. Bolton, Jr., treasurer of John W. Bolton, cosponsors with the Paper Industry Management Association, presented Mr. Bagg with his check and a hand engrossed, laminated wall plaque prepared for the occasion.

James C. Lannen, personnel supervisor, Fraser Companies, Ltd., Atholville, N. B., received a $750, 2nd-prize check for his essay. Presentation of the prize and a personalized wall

Robert A. Bagg (left) receiving first prize for his essay from A. L. Bolton, Jr., while F. Nelson Bridgham (2nd from left) and John E. Benedict look on

plaque was made by John G. Bolton, president, John W. Bolton & Sons, Inc., which company sponsors the annual contest with the Paper Industry Management Association, Chicago.

Canadian Industries, Ltd.

Fluolite MP Liquid

A new fluorescent whitening agent, designed particularly for use in the paper industry, has been introduced in Canada by the chemicals division of C-I-L.

Known under the trade name, Fluolite MP Liquid, the new product was developed by I.C.I.'s dyestuffs division for which C-I-L is exclusive Canadian agent.

Although quality of the whitening effect produced by this agent when used at low concentrations is generally similar to that given by an older agent, Fluolite C, it is markedly superior when higher concentrations (about 4 lb. per ton of pulp) are required. The new agent is, thus, better adapted to the production of "super" whites.

Literature on the new product is available from Chemicals Division, Canadian Industries, Ltd., Box 10, Montreal, Que.

The Celotex Corp.

Appointment

William M. Lehmkuhl, has been appointed manager of the Louisiana division of the Celotex Corp. He was previously works manager of the corporation's plant in Marrero.

Jerry L. Dickson, manager of the engineering department in Marrero, will replace Mr. Lehmkuhl as works manager.

Colton Chemical Co., Division of Air Reduction Co., Inc.

Vinac AA-63 Improves Adhesives Formulations

Developed for adhesives compounding by Colton, Vinac AA-63 is compatible with solutions of fully hydrolyzed polyvinyl alcohol.

The noncreaming properties of Vinac AA-63 prevent fully hydrolyzed PVA solutions from separating upon aging and also impart more water resistance to finished adhesives.

Other characteristics of Vinac AA-63 are: normal compounding with solvents (carbon tetrachloride, toluene) and conventional plasticizers; excellent mechanical stability; low viscosity index; good machining properties.

Technical data are available from Colton Chemical Co., a division of Air Reduction Co., Inc., 1747 Chester Ave., Cleveland 14, Ohio.

Combustion Engineering, Inc.

Offices Move to Windsor, Conn.

The general offices of Combustion Engineering, Inc., located in New York for more than 45 years (35 years in the Combustion Engineering Building at 200 Madison Ave.) have been transferred to Windsor, Conn., 125 miles away.

The move was necessitated by the continuing growth of Combustion which made it essential to plan for offices with greater floor areas than were available at its New York location. The selection of Windsor was largely influenced by the fact that the company owned a 530-acre tract there, acquired in 1955 as the site of its Nuclear Division. The property included a sizable modern office building, adaptable to enlargement. In order to accommodate the departments being moved, a 250-ft. long wing has been added to this building, and a new separate building has been constructed to house the Nuclear Division staff.

Certain officials and the New York District Sales, Export, Marine Sales and Service, and Publicity Departments will remain at 200 Madison Ave. in New York where the company is retaining four of the 13 floors it previously occupied.

The mailing address at the new corporate general offices is Combustion Engineering, Inc., Windsor, Conn., and the telephone number is Murdock 8-1911, long distance area code 203.

Dorr-Oliver, Inc.

Continuous Processing Bulletin

A new revision of the 16-page brochure, "Continuous Processing," Bull. No. 7004, illustrates and lists the distinguishing characteristics and applications of 55 types of continuous processing equipment manufactured by Dorr-Oliver, Inc., Stamford, Conn. Pilot plant equipment is also described, with special emphasis on classification, centrifuging, filtration, and fluidization.

Dorr-Oliver Bulletin No. 7004 is available free to readers of this publication.

Diamond Alkali Co.

Appointment

Charles P. Egolf has been appointed assistant manager of Diamond's southeastern sales office in Memphis, Tenn.

To this newly-created position in which he has been serving since March, Mr. Egolf brings a background of 14 years' experience as a salesman and research chemist. He joined Diamond in 1953 as a field salesman becoming a senior salesman two years later.

Frank W. Egan & Co.

Appointments

Frederick A. Gill has been named sales engineer in the paper division of the company Somerville, N. J.

Mr. Gill served five years as a development chemist and engineer for Plastic Coating Corp., Holyoke, Mass., and four years previous to that as an analytical chemist with Johns-Manville Research Center, Manville, N. J.

Another addition to the Egan staff is Milton G. Ludwigson who has been assigned to the engineering department.

Goulds Pumps, Inc.

Tulsa Southwest Sales H. Q.

W. H. Plowman, manager of southwest sales for Goulds, with offices in Tulsa and Houston, is now permanently located in Houston having moved there from Tulsa where he has been for the past several years.

Hooker Chemical Corp.

Appointment

Jack W. Knapp has been transferred to the sales department

of Hooker's Western Chemical Division, Tacoma, Wash.

A buyer for the Tacoma plant for the past five years, Mr. Knapp joined the company there in 1949.

H. Clark Lind

Huyck Felt Co., Division of Huyck Corp.

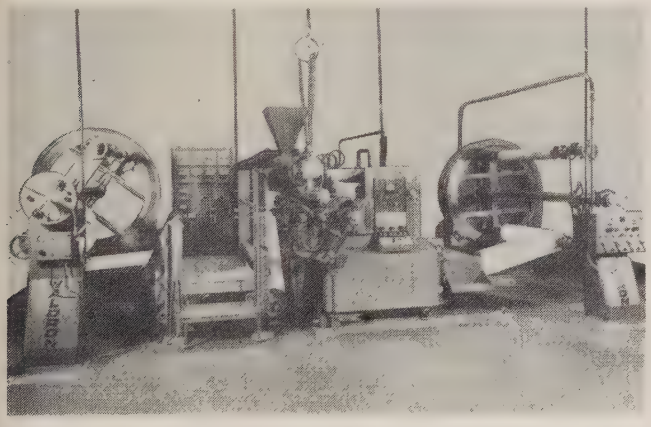
Appointment

H. Clark Lind has been appointed research engineer. Mr. Lind, a paper engineering graduate of Lowell Technological Institute, was previously employed as a development engineer for Texon, Inc., South Hadley Falls, Mass.

The Marvellum Co.

New Polyethylene Extruder-Coater

A 54-in. polyethylene extruder-coater, embodying the most modern design features available to assure controlled film thicknesses and continuous operation has been installed at The Marvellum Co., Holyoke, Mass. The new addition will enable Marvellum to supply poly-coated paper for packaging sugar and other dry foods, multiwall bags, freezer or locker paper, nursery wraps, and decorative as well as protective ream and roll wrappers. Polyethylene combinations for food packaging and many other applications will also be available.



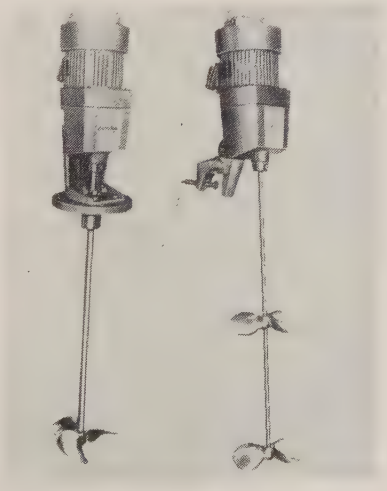
The 54-in. polyethylene extruder-coater

This new extrusion line was designed especially for Marvellum by the Waldron-Hartig Division of Midland-Ross Corp. in cooperation with Marvellum's own technical staff.

Mixing Equipment Co., Inc.

New Lightnin Line of Portable Mixers

A completely new line of Lightnin propeller-type portable mixers for fluid agitation in process industries has been announced by Mixing Equipment, Rochester, N.Y. Designed as an integral unit, the new mixer offers increased mixing efficiency, improved handling convenience, and maintenance-free operation. It will be marketed in sizes ranging from $^1/_8$ to 3 hp., and will also be available in a fixed mounting design in all except $^1/_8$ hp. sizes.



The new Lightnin mixers offer direct-drive speeds of 1750 and 1150 r.p.m. with higher impeller heads, and a gear-drive model speed of 350 r.p.m. providing up to 45% more flow than previous units.

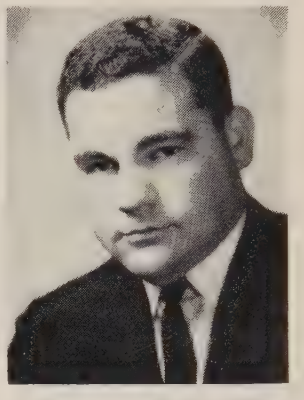
In the portable line, optimum mixing efficiency is assured by means of a position-indexing device on the housing ball and clamp socket. The mixer can be adjusted 90° in the vertical and 360° in the horizontal plane. The index pinpoints the mixer's optimum position and facilitates repositioning in a simple, quick operation.

Morden Machines Co.

Appointments

Ivan Kuhns has been appointed a sales and service engineer in its southern region.

Mr. Kuhns, comes to Morden from the Erie, Pa., plant of Hammermill Paper Co., where he was a senior engineer. He will devote a substantial amount of his time to Morden pulpers and the introduction of the new Morden Disco-Finer.



Ivan Kuhns

Mr. Kuhns received his degree in mechanical engineering from Tri-State College, Angola, Ind., in 1954. After serving with the United States army in Germany for two years he joined Hammermill Paper Co. as engineer.

Mr. Kuhns will make his Headquarters in Atlanta, Ga.

Nalco Chemical Co.

Organo-Sulfur Slimicides

Two new organo-sulfur slimicides said to have superior killing and dispersion action on mill microorganisms have been announced by Nalco.

Available in a liquid form called Nalcon 242, and a ball briquette form called Nalcon 245, both have strong anionic dispersant properties. Neither contains phenolic materials nor heavy metals. These have built-in bactericidal, fungicidal and dispersant characteristics specifically for control of the troublesome slime formers in pulp and paper mill systems. Both have been approved by the FDA for use in food packaging papers.

Acid Medium Antifoam

Development of a new antifoam formulated specifically to function under the acid conditions encountered in paper machine operation is announced by Nalco.

The material, a liquid blend of esters, emulsifiers and surface active agents, is called Nalco 71-M. It is designed to break up visible foam, control bubble formations and free entrapped air to prevent foam from occurring.

The new antifoam has a freeze-thaw recovery of 30°F. and a cloud point of 30°F. It emulsifies instantaneously, without stirring, even in water as hard as 400 p.p.m.

National Starch and Chemical Corp.

New Resin Development Booklet

Technical data on polyvinylidene chloride latex, Resyn 3600, has been compiled into a special booklet (Technical Bulletin 340) which is now available from the company's Resin Division, 750 Third Ave., New York 17, N. Y.

Resyn 3600 is an aqueous dispersion of vinylidene chloride copolymer. Its outstanding combination of barrier and application properties will enable its use as a protective coating for packaging materials and a variety of applications are also feasible in the textile, construction, paper, agricultural, and other industries.

Pennsalt Chemicals Corp.

$6-Million Modernization of Chlorine-Caustic Facilities

Modernization of its largest chlorine-caustic plant in Wyandotte, Mich., has been completed on schedule by Pennsalt. The largest single modernization project undertaken by the company, it included the replacement of some 5000 old diaphragm-type electrolytic cells with 200 large, modern, 30,000-amp. cells.

Installation of the new cells was preceded earlier this year by the installation of modern caustic evaporating and brine treatment facilities. The total program cost $6,000,000.

In addition to providing increased output of chlorine, caustic soda, and hydrogen, the new cells will afford considerably greater operating economies.

Prenco Engineering

Contract for Groundwood Slush Pulp Handling System

Prenco Engineering, a chemical and mechanical engineering firm organized last year by C. L. Fluno and F. A. Emmerling with offices at 50 Unity Building, Watertown, N. Y. has been awarded an engineering contract for a new groundwood slush pulp handling system for the Stevens & Thompson Paper Co., Greenwich.

This new stock-handling system is part of a $250,000 modernization and improvement program planned by the Stevens & Thompson Co. It is expected the new system will be installed in time to permit operation by November 1.

The Stevens & Thompson Co. is one of the oldest paper mills in operation in the state, having been established in 1868. The mill manufactures facial and bathroom tissues, toweling, paper plates, and trays.

The Prenco firm offers industrial and process engineering to pulp and paper companies as well as various types of chemical process industries.

J. O. Ross Engineering Div., Midland-Ross Corp.

Promotion

David R. Alexander has been transferred from the Boston to the New York office of J. O. Ross.

Mr. Alexander is a 1956 mechanical engineering graduate of the University of Maine, where he completed the five year Pulp and Paper course.

Stickle Steam Specialties Co.

Moisture Detector with Adjustable Sensitivity

Bulletin 300-F describes the new Stickle detector with an adjustable sensitivity to automatically control moisture content of any weight of paper during drying. A hand dial on the detector permits setting of any desired sensitivity, and gives extremely fine regulation to prevent cycling.

The detector is designed primarily for use on machines running paper as light as 0.0003, and on those running a wide range of basis weights. Any setting may be duplicated exactly when the same weight is rerun.

The bulletin is available free from the manufacturer, Stickle Steam Specialties Co., 2215 Valley Ave., Indianapolis 18, Ind.

Testing Machines, Inc.

Sampling from a Moving Web

TMI announces the availability of a data sheet which illustrates and describes the TMI paper sampler. The unit is designed for use on comparatively slow moving webs of speeds up to approximately 400 f.p.m.

For complete details write to Testing Machines, Inc., 72 Jericho Turnpike, Mineola, N. Y.

U. S. Industrial Chemicals Co.

Booklet on Polyethylene Bulk Handling

A 24-page booklet on the advantages of bulk purchasing and handling of polyethylene resins has been published by U. S. I. C. The booklet analyzes in detail, with the help of photographs, diagrams, charts, and tables, the factors to be considered in bulk ordering and handling of these materials, with particular reference to Petrothene* polyethylene resins.

A comparison is made of the two most commonly used methods of polyethylene bulk purchasing, the Dry-Flo(R) railroad car and the Sealdbin(R) rubber container.

Copies of the booklet may be obtained by writing to Technical Literature Dept., U. S. Industrial Chemicals Co., 99 Park Ave., New York 16, N. Y.

Union Carbide Chemicals Co.

Polyalkylene Glycol Fluids and Lubricants

A new 52-page booklet, describing the properties and uses of Ucon polyalkylene glycol fluids and lubricants, has been published by Union Carbide Chemicals Co.

The booklet contains comprehensive data on the 32 types of Ucon synthetic fluids and lubricants available from Carbide. Included are physical properties, physiological properties, physical and chemical analytical methods, storage and handling instructions, and a special section on the selection of the proper Ucon fluid or lubricant for any given application.

Western Precipitation Div., Joy Mfg. Co.

Appointment

Patrick W. Zilliacus is general sales manager of Western Precipitation, Los Angeles, Calif.

Mr. Zilliacus was formerly manager of agency sales for the division, and had been manager of the standard fan and dust collector products department of Joy at New Philadelphia, Ohio, from May, 1957, to November, 1959. Previously he was administrative assistant to the vice-president and general manager, Industrial Division at the Joy executive offices in Pittsburgh, Pa.

Before his association with Joy in 1956, Mr. Zilliacus was manager of the Perkasie, Pa., plant of the Fruehauf Trailer Co. and has served in an engineering capacity for RCA at Camden, N. J.

Westinghouse Electric Corp.

Circle W Trademark and Logotype Redesigned

The logotype—the way the word "Westinghouse" is printed in corporate communications, advertising, signs, and name plates—has been redesigned so that it is compatible with the new trademark.

The new trademark still retains the traditional circle but the dimensions have been changed and three small solid circles have been added to the peaks of the W.

The new companion piece of the trademark, the logotype, has been designed in a semicondensed Gothic type. The logotype it replaces was a form of Caslon type.

* Registered Trademark of National Distillers and Chemical Corp.

Wisconsin Wire Works

Host for Technical Studies

First guest attending a new series of cooperative technical studies by the Wisconsin Wire Works on the manufacture of fourdrinier wires was D. E. (Dave) Jones, paper superintendent of the St. Regis Paper Co., Pensacola, Fla. Mr. Jones, along with Horace B. Hill, Jr., WWW representative from the southern area spent several days in June at the company's home plant in Appleton, Wis.

During this period, the intricacies of the preparation of the raw material through the wire drawing department to the final weaving and finishing processes involved in the manufacture of a fourdrinier wire were explained and demonstrated in detail to Mr. Jones. Discussion and exchange of ideas and experiences between Mr. Jones and technical specialists of the Wire Works were also an important part of the visit.

According to James E. Watson, president of Wisconsin Wire Works, these cooperative technical studies and discussions are extremely important to the company's efforts in producing improved fourdrinier wires, both for better paper formation and longer wearing life. The company is conducting a series of such cooperative meetings with other mill representatives of the paper industry.

Appointment

John F. Howell has been appointed as representative for paper mill wire cloth in the state of New York. Mr. Howell previously represented a leading felt manufacturer in the paper industries.

George Clayton who previously served New York state for Wisconsin Wire Works, Appleton, Wis., has been reassigned to Virginia and West Virginia.

General

Tropical Starch Imports

The United States cornstarch industry, which manufactures its products from American price-supported corn, has been "effectively excluded" from most foreign markets and now is rapidly losing its domestic market to imports from low-wage countries. A. E. Staley, Jr., chairman of the board of directors of the A. E. Staley Mfg. Co., Decatur, Ill., and representative of an industry group composed of all U. S. cornstarch producers, called for remedial action by government trade-policy makers.

Appearing before the Committee for Reciprocity Information, Mr. Staley urged that no further tariff reductions be granted on foreign grain starches and that, instead, an increase in American duties on those starches be negotiated. He pointed to tapioca and sago as the most serious danger to the American industry because they are allowed to pour into the United States duty-free in uncontrolled amounts; the principal source countries, Thailand and Brazil, impose high tariffs on all starches they import.

He also called attention to the protective tariffs on starch imports established by European countries in recent years, adversely affecting American sales abroad. He recalled that the Staley company once shipped a major portion of its production overseas but today it can market only an "infinitesimal" part of its output in foreign areas.

Paper Suits for Atom Workers

Disposable paper suits have been added to the atomic-age wardrobe.

The paper clothing—pants, coats, and even a matching hat—is provided for personnel who work with radioactive materials at General Electric's nuclear equipment plant here.

The atom workers, in joining with electronic and drug industry employees as users of the new type of clothing, report the paper clothes are lighter, cooler, and more comfortable than normal work clothing.

They also give an additional safety factor to workers—already protected by rigorous safeguards—because they are more impervious than the conventional cloth overalls.

The suits, made of heavy-duty, fire-and-water-resistant, nylon-threaded paper, are being worn in controlled areas of the plant's nuclear fuel manufacturing operation, as well as in the company's Vallecitos Atomic Laboratory.

They are worn only once or twice, then burned in an incinerator specially designed for the disposal of materials which—like the paper clothes—might possibly have picked up some radioactive dust particles.

The paper suits cost about $1 each. This is considerably less expensive than having normal work clothing cleaned in a special "atomic laundry," as at most atomic installation.

General Electric's Atomic Power Dept. using about 1000 of the paper suits a month, estimates it will save $10,000 in the fuel manufacturing area this year by using the paper clothes.

W. Willets Elected ASTM Director

William R. Willets, Assistant Manager of the Technical Service Laboratories in charge of the Paper Section of the Titanium Pigment Corp. (a wholly owned subsidiary of the National Lead Co.), received his B.S. degree at the State College of Forestry, Syracuse, N. Y., in 1926. From 1926 to 1929 he was research chemist with the Oxford Paper Co.; and from 1929 until 1933, engineer, Pulp Insulation, for the Western Electric Co. He has been employed by the Titanium Pigment Corp. since 1933, except during a period from 1942 to 1944 when he served as a consultant to the Conservation Division of the War Production Board on Pulp and Paper and Printing and Publishing.

W. R. Willets

Mr. Willets has been a member of ASTM since 1937 and has served on ASTM Committee D-6 on Paper and Paper Products since that time. He was chairman of the committee from 1948 to 1956. He has represented Committee D-6 on ASTM Committee E-12 on Appearance since 1946, and has been a member of ASTM Committee D-25 on Casein and Similar Protein Materials since the committee was organized in 1956. He is active on numerous subcommittees of each technical committee and was formerly a member of ASTM Committee D-9 on Electrical Insulating Materials.

Mr. Willets is author or co-author of over 50 articles and monograph chapters dealing mostly with the paper industry and its technology. He is Secretary-Treasurer of the Society of Rheology, a member of the Governing Board of the American Institute of Physics, member of the American Chemical Society, Fellow of the American Institute of Chemists, member of TAPPI (past chairman, Empire State Section, and chairman of two technical committees), member of Alpha Chi Sigma and Alpha Xi Sigma (see TAPPI Profiles this issue).

Report on Baling Wastepaper

A new Ideas-in-Action report, available from Acme Steel Co., Chicago, Ill., describes the methods used by various companies to bale wastepaper with steel strapping.

The four-page illustrated report shows how these companies have achieved tighter, more compact bales, lower material costs and greatly increased baling output. The Acme Steel fully powered A4 Steelstrapper is particularly suited for

baling. Air power does the tensioning, sealing, and cutting off of the flat steel strapping. Tension of the steel strapping is predetermined so that bales are uniformly compact and equal in size and shape providing easier handling and loading.

Several different types of baling operations are illustrated.

Copies of the report are available from Acme Steel Co., 135th Street & Perry Ave., Chicago 27, Ill. Ask for report No. S6-12.

New Chemicals Increase Paper Life

The deterioration of paper has become a serious problem of librarians, archivists, and other record keepers. In an extensive study of paper permanence carried out by the Virginia State Library, they estimated that 90% of the paper produced over the last half century had a useful life under 50 years. This study, recently published, also reports that it is possible now to make paper having a useful life of 400 years or more.

Until recently, paper has had a long useful life owing to the manner in which it was made. Early papers were made under alkaline conditions, using readily available rags for pulp and animal glue for sizing. In the last hundred years, however, the greatly increased demand for paper and the continual lowering of its price have necessitated many changes in papermaking.

The supply of suitable rags is now more limited, requiring the substitution of wood pulp in its place. Glue, too, has been replaced with other sizing chemicals, generally acidic in nature. This combination of changes has resulted in the relatively short life of modern papers. Many librarians refer to the past 60 years as a "Lost Era" because printed matter from this period will soon deteriorate and be lost to succeeding generations unless reprinted.

The Virginia State Library study reports that by replacing acidic chemicals with new papermaking chemicals able to function under alkaline conditions, and filling the paper with calcium carbonate which acts as a buffer, long-lasting paper can be made from wood pulp.

For sizing they used Aquapel and for retention of calcium carbonate they used Kymene 557, products of Hercules Powder.

This type of permanent paper was developed by the well-known restorer of documents, W. J. Barrow, under a grant to the Virginia State Library by the Ford Foundation's Council on Library Resources.

Water—A Safety Hazard

Water, vital in conversion of pulp to usable paper, is one of that processing industry's major safety hazards. This danger from water, often mixed with oil, occurs in the lower level of most paper mills—beneath mammoth drying presses and calenders. Here, maintenance men chance injury from slips and falls to check oil tanks, stock pumps, and other machinery. To solve this problem, one firm, St. Regis Paper Co., has employed a nonskid surfacing material for 1400 sq. ft. of walkways in its Printing Paper Division plant in Bucksport, Me.

Much of the water used in processing fine print papers at St. Regis falls from suction boxes, positioned just after the flow box, into a tank. However, the remaining press and drier operations cause a considerable amount of condensation. And, there is "wash down" from the second level. Often oil, dripping from bearings on upper level machinery, mixes with the condensed water. The smooth concrete floor remained slippery despite frequent hosings with a combination of steam and strong detergent.

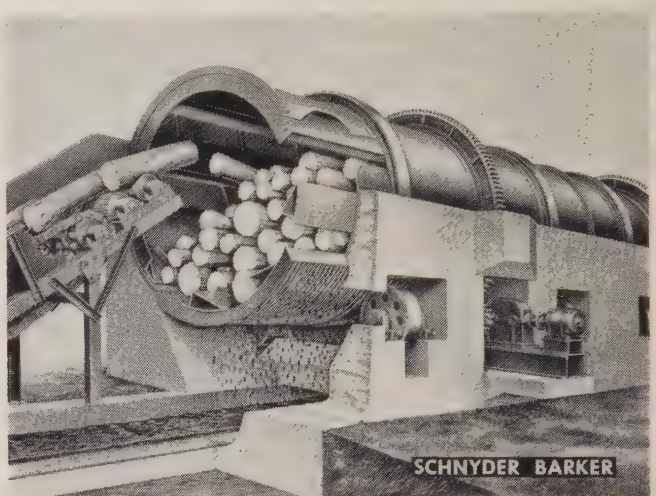
To reduce the danger of men slipping and falling, Safety Director Brooks, Plant Engineer Steve Barry, and supervisors on the safety committee decided to try a nonskid surfacing material that was a combination of bonding resin and grit particles.

Using yellow to match other plant safety colors, 14 gal. of M-S-A Dura-Grip were used to cover 1400 sq. ft. of walkways and other areas where there was danger of slippery footing. The first coat of bonding mix was applied and sprinkled with the gritlike particles. This dried for $1^1/_2$ hr. and excess grit was swept away. Then the top coat of bonding resin was applied. It dried for light traffic in 6 hr. and heavy traffic in 16 hr.

Initial application of this surfacing material, supplied by Mine Safety Appliances Co., Pittsburgh, was made in August, 1959, and followup uses in other lower level danger areas were made three months later. The applications proved durable in spite of heavy traffic, and punishing effects of the frequent hosings with steam-detergent mixture.

The result? There has been no slip or fall report since the material was put down.

The Schnyder Barking Tunnel



An invention has been claimed for barking commercial size pulpwood ranging from 4 to 10 ft. in length and 4 to 24 in. in diameter. Its design has just been completed but no installation is in existence yet. The first public disclosure was made by A. P. Schnyder, Consulting Engineer, at the 41st Annual PIMA Meeting held in San Francisco, June 8, 1960, and a patent has been applied for. This barking tunnel includes working parts of the conventional, trunion-type barking drum. The revolving drum proper is replaced with an "open" scroll sweeping the circular tunnel which supports the logs. The logs are fed horizontally by overspeed rolls into the tunnel where they are rolled around, and advance by the triangular pusher elements of the scroll. The logs are bedded roughly parallel. Barking action is predominantly by friction as well as by some impact against the concrete tunnel wall. Bark release is direct through an almost continuous grillage which also limits the maximum size of bark particles and prevents long strings

OBITUARY

John Paul Ekberg

John P. Ekberg, a director and retired vice-president of the Chesapeake Corp. of Virginia, West Point, Va., died July 21, 1960, in Greenwich, Conn.

Mr. Ekberg was born Jan. 25, 1884, in Ystad, Sweden, and was educated at the Royal Polytechnic Institute. On graduation in 1907, he went to the Oxford Paper Co., Rumford, Me. He was connected with the Brompton Pulp & Paper Co., Deerfield Pulp Co., and the Aroostock Pulp Co. before joining the Chesapeake Corp. in 1919 as general superintendent.

Mr. Ekberg became a member of TAPPI in 1942.

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Coating and Graphic Arts Division

Coating Committee

A meeting was held during the 11th Coating Conference, May 23, 1960, at the Edgewater Beach Hotel, Chicago, Ill.

MINUTES

The minutes of the meeting of Feb. 22, 1960, held at the Commodore Hotel in New York were approved after a motion to accept the minutes as written was proposed by R. T. Trelfa and seconded by C. Kessler.

PROJECT NO. 536—FLOW PROPERTIES OF COATING COLORS (J. Wilber)

The request for additional funds to continue work at the University of Maine has been granted and approved by the Project Appropriations Committee.

Glen Hemstock summarized the progress made in the past 10 months. An inclined plane viscometer has been built. The relationships between coating viscosity and film splitting will be studied first. Newtonian systems will be investigated before tackling non-Newtonian coatings.

Karo (corn sirup) has been selected as the Newtonian vehicle for the preliminary phases of this work. Mr. Kessler questioned the selection of Karo as a Newtonian liquid and asked to see the viscosity data which indicate it is.

A progress report will be issued in mid-September by Dr. Durst of the University of Maine.

MONOGRAPHS (C. Landes)

The monograph entitled "Protein and Synthetic Adhesives" is now in the hands of the printer. Mr. Landes pointed out that eight out of 21 monographs published by TAPPI was sponsored by the Coating Committee.

Project No. 303—Monograph on Paper Coating Additives. Ray Hall reported that good progress has been made and predicted that all chapters will be finished by the next committee meeting.

Project No. 796—Monograph on Pigmented Coating Processes for Paper and Paperboard. George Booth reported that some 20 authors have been obtained but that an additional 12 would be required to cover the various facets of the monograph. The exact title has not been established. Due date for all chapters has been set for late 1961.

New Monographs. Mr. Landes asked the committee for suggestions and ideas on possible new monographs. He pointed out the importance of these monographs as a source of information particularly to the young scientists entering the field of coated paper.

PROJECT NO. 600—PARTICLE PACKING

J. V. Robinson, chairman of this subcommittee, reviewed the progress which has been made and analyzed the problem of continuing the project on a voluntary basis. Because the basic nature of the project requires close technical supervision as well as specialized equipment, Mr. Robinson felt that the project was too costly, both in personnel as well as dollarwise, for one or two mills or suppliers to underwrite and recommended that the project be turned over to the Pigments Studies Subcommittee for further consideration and action. He expressed his views on the importance of this work and suggested that the project be continued at a suitable research center with TAPPI funds. A motion to turn Project 600 over to the Pigments Subcommittee was made by M. Cushing, seconded by R. N. Thompson. Motion passed.

MEMBERSHIP (F. Kaulakis)

The Coating Committee membership numbers 95. However 12 of the members missed two consecutive meetings without a notice of absence and have been notified of cessation of their membership. There are seven new members.

DATA SHEETS (R. W. Hagemeyer)

L. Georgevits reported that data for various pigment slurries is ready for publication. The effect of various alkalis on the pH and viscosity of casein and protein solutions will also be available in the near future.

LIAISON REPORTS (R. W. Hagemeyer)

ASTM Committee on Protein Adhesives (D-25). J. Voit, TAPPI representative to the ASTM D-25 committee reported that at the subcommittee on nomenclature had selected "isolated protein" as the proper name for refined soya protein.

Routine Control Methods (J. Gunning). Submittal of test methods by suppliers has been good whereas response from the paper mills has been poor.

COATING CONFERENCES

Twelfth Coating Conference, Statler-Hilton, Buffalo, N. Y., May 22–24, 1961. R. W. Martinek, general chairman, reported that the theme will be "Adhesives for Coating." Response for papers has been good and an early submittal of papers was recommended. C. G. Whelpton of Champion Paper and Fibre Co. is chairman of the technical program.

1962 Netherlands-Hilton, Cincinnati, May 22–24.

1963 French Lick-Sheraton, French Lick, Ind., May 19–22.

1964 New Orleans—Hotel and date to be announced later.

SUBCOMMITTEE REPORTS (F. Kaulakis)

Pigment Studies (W. R. Willets). Mr. Willets reported that the response to his letter of April, 1959, asking for opinions on a number of specific problems was practically nil. He urged submittal of ideas for specific projects for consideration by the subcommittee. The Armour Research Foundation has submitted a project suggestion entitled "Prediction of Brightness and Opacity of Coated Paper." This proposal is being studied. The possibility of tieing Project 600 in the Armour proposal was discussed.

Adhesives Studies (M. L. Cushing). Mr. Cushing reported that since his appointment as chairman last February, a subcommittee has been organized and an attempt will be made to hold a formal meeting before the 1961 TAPPI meeting to consider suggestions for possible projects.

Factors Affecting Coat Weight (R. J. Jacobs). Mr. Jacobs, who was appointed chairman of this subcommittee last Febru-

ary, reported that he has three members on the subcommittee and would like additional members to work on this project. He distributed a 7-page memorandum prepared by D. Willenbrock listing mechanical factors affecting coating weight.

New Projects (J. Frankevicz). Mr. Frankevicz submitted the following proposals for new projects:

1. A subcommittee be formed to prepare a list of ideas which could be circulated to various graduate schools to stimulate interest and research projects on coated paper.
2. What is the effect of pressure in the coating unit on the rheology penetration and other properties of coating colors.
3. Survey literature and compile list of factors affecting ink absorbency of plain and coated paper.

Mr. Wilbur will appoint chairmen to form subcommittees on proposals 1 and 2.

New Business.

None.

Chairman Wilber expressed his appreciation for the cooperation of those in attendance. A motion to adjourn was passed at 10 a.m.

Frank Kaulakis, *Secretary*

Converting and Consuming Division

Extrusion Coating Subcommittee—Plastics Committee

The Extrusion Coating Subcommittee held an exploratory meeting on Tuesday, May 24, at the Edgewater Beach Hotel, Chicago, Ill., during the TAPPI Coating Conference. The meeting was attended by 21: twelve from companies engaged in extrusion coating, three from resin manufacturing companies, four from machinery builders, and two from research organizations. In addition, representatives of five resin manufacturing companies and five companies engaged in extrusion coating wrote advising they could not attend the meeting but were interested in participating in the proposed Extrusion Coating Subcommittee. The secretary-treasurer of Specialty Paper & Board Affiliates, Inc., wrote as follows: "On behalf of our Polyethylene Extrusion Coaters Group, I would like to indicate that there is considerable interest among the members in the establishment of such a subcommittee and a reactivation of Project No. 586–Adhesion of Polyethylene Coatings to Paper."

At the meeting in Chicago, a general discussion was held on the need for a group within TAPPI devoting its attention to paper problems as related to extrusion coating with all types of resins. Extrusion coaters, resin suppliers and machine builders alike agreed that there could be a free flow of information. The point was made that the committee should devote itself to basic research rather than attempt to solve day-to-day operating problems.

With regard to the reactivation of Project No. 586—Adhesion of Polyethylene Coatings to Paper, it was decided that additional work must be done by the subcommittee before a new request is made to TAPPI Headquarters. As a start, John Schornagel of H. P. Smith Paper Co. and Joseph Pilaro of U. S. Industrial Chemicals Co. will assist the subcommittee chairman in preparing a questionnaire on adhesion test methods. This questionnaire will attempt to determine the most commonly used test method for several types of paper and paperboard. For instance, the committee hopes to establish what test method is most commonly used for multiwall bag stock, for bleached board, and for pouch papers. If it is found that a test method is in general use for a particular type of base stock, then a round-robin test will be run using a standard sample to see if a degree of correlation and reproducibility can be established for these tests.

It is hoped that the questionnaire, followed by the round-robin, will be the first step in producing a definition of the term "adhesion of polyethylene coatings to paper." After this point has been reached, discussions will be held with several research organizations to determine:

1. The possibility of improving the specific test method.
2. Using the test method to make a study of the paper properties which affect the adhesion of polyethylene coatings to paper.

It is anticipated that the questionnaire on test methods will be mailed out in July and that a report can be submitted to the Plastics Committee during the Plastics Conference in Syracuse, Oct. 17–19, 1960.

James S. Thornton, *Chairman*

Engineering Division

Subcommittee—Corrosion Committee Pulp Purification

The Pulp Purification Subcommittee of the TAPPI Corrosion Committee met on Monday, June 13, 1960, at the Edgewater Beach Hotel, Chicago, Ill., to discuss corrosion problems and materials of construction in pulp purification. This meeting was held to and in conjunction with the Pulp Purification Conference. About 45–50 members of the Corrosion and Pulp Purification Committee plus guests attended the morning and afternoon sessions.

The morning session was generally devoted to a discussion of metals, metal failures, and recommended metals for chlorination, hypochlorite, and chlorine dioxide service. Among the metals discussed were types 316 and 317 stainless steel, Hastelloy C, titanium, and lead. The use of glass-lined steel was also considered.

The afternoon session was involved principally with the use of plastics and fiberglass-plastic laminates, plastic films, and acid resistant brick and tile, and surface preparation before coating.

It was announced at the meeting by R. E. L. Wheless, Union Bag-Camp Paper Corp., Franklin, Va., chairman of the subcommittee, that a questionnaire has been prepared and will be sent to all pulp mills with chlorine dioxide bleach installations, asking for information regarding their corrosion problems in these systems. This project will be TAPPI Project No. 839.

The meeting was worth while. It developed information based on actual plant experiences with various materials under specific conditions together with specific answers based on technical experiences and backgrounds. The major item discussed was corrosion involved in chlorine dioxide service. Attention was paid to the manufacturing of chlorine dioxide and its handling and to the bleaching and washing of the pulp. The following covers some of the topics discussed.

In sodium chlorate storage and dissolving tanks carbon steel has not been satisfactory. It has rusted and perforated, generally above and at the liquor level. Type 304 stainless clad, tile lined carbon steel, glass lined carbon steel, and fiberglass-epoxy-phenolic impregnated linings in steel tanks were reported to have been used successfully. It was reported that the epoxy-phenolic fiberglas laminate could not be successfully installed in carbon steel tanks previously subjected to sodium chlorate solutions. Aluminum, type 3003 for storage and dissolving tanks is under consideration.

Both homogeneous lead and glass lined chlorine dioxide generators have been employed. There have been difficulties with each type due to perforations or cracks in the coatings. Both types can be repaired, the lead by lead burning, the glass lined by use of tantalum plugs or patches and teflon gaskets. It was mentioned that hydrochloric acid washed out of gas and running down the lead lining could cause severe attack. A question regarding the use of titanium tubes for introducing sulfuric acid brought an answer that titanium was not suitable for sulfuric acid service.

Pulp Purification Subcommittee of TAPPI Corrosion Committee: R. E. L. Wheless, Union Bag-Camp Paper Corp., chairman

Pulp Purification Subcommittee of TAPPI Corrosion Committee: R. E. L. Wheless, Union Bag-Camp Paper Corp., chairman of the subcommittee; E. W. Hopper, Pittsburgh, Pa., chairman of the Corrosion Committee; and A. O. Caldwell, Service and Erection Co., Pittsburgh, Pa., secretary of the Corrosion Committee

The chlorine dioxide single shaft mixers have been constructed using type 317 stainless steel, Hastelloy C, and titanium. The type 317 stainless shells and agitators gave limited service. The life of the Hastelloy C liners in steel shells has been irregular. In many cases the liners have failed rapidly. In some cases solid Hastelloy C shells have failed. However, in some mills, the Hastelloy C liners and shells have given good service, particularly when the chlorine dioxide has been introduced by titanium inlet nozzles into the center of the stock stream. The agitators have generally been of cast Hastelloy C and show attack. It was reported at the meeting that all Hastelloy C should be purchased specifying the analysis required and that all Hastelloy C should be properly annealed, "otherwise money was being thrown away." The annealing of Hastelloy C calls for soaking at 2250°F. ± 25°F., preferably followed by a water quench to cool to black in 5 seconds, and to cool to black in a maximum of 45 seconds.

Titanium has been used for mixer shell liners and inlet nozzles. The service to date has been excellent. No failures have been reported. The welding is critical and welds must be protected from air, carbon, and moisture. This requires the best in gas shielding. It was reported that there are 25 mixers with titanium linings in service or on order.

Hastelloy C agitators in up-flow towers have shown good and poor service life. This may have been due to faulty chemical analysis and failure to anneal properly. At least one Hastelloy C agitator has been replaced with titanium.

Attempts have been made to line mixers with fiberglas-polyester impregnated. With wear and rubbing, the liners have cracked, allowing attack under the lining.

The goose necks from the mixers to the towers have been constructed of type 317 stainless and Hastelloy C. The 317 stainless was inadequate. The Hastelloy C, especially where annealed has given good service life.

The agitators, dilution inlet nozzles and thermo wells in the retention towers have been installed in stainless 317 or Hastelloy C. The stainless in some instances has pitted and developed heavy, rusty tubercles wherever pulp adhered to the surface. The Hastelloy C has been satisfactory in this service generally although one agitator in an up-flow tower was replaced with a titanium unit.

The retention towers have been carbon steel shells with a membrane lining between the shell and a course of acidproof brick set in a polyester-resin cement. In many cases a plasticized polyvinyl chloride membrane has been employed. Recently a latex-luminite cement coating has been applied to the steel shell and subsequently coated with Sarancote to form the membrane. The evidence so far would tend to show that the upper limit in temperature for long time exposure of PVC membranes to chlorine dioxide containing stock is about 135°F. Above this temperature the PVC membrane tends to harden, turn white and brittle, and crack. The statement was made that the acid brickwork is present to protect the membrane from high temperature and abrasion. Therefore, with tower temperatures as high as 170 to 180°F., the brick and pointing should not permit leakage of hot liquor back to the membrane to a degree that would allow the membrane to reach temperatures over about 135°F. Wide, unfilled joints in the brickwork should be repointed. It was stated that to allow for good repointing, a joint about $^3/_{16}$ in. wide should be employed. There have been cases where considerable repointing was required after 18 to 24 months. Some of this was due to improper original pointing. Some polyester joints examined after 18 months to 5 years have been in excellent condition.

The tops of some upflow retention towers have been a source of trouble. The protective coatings applied to the metal tops have been inadequate and failed due to blistering, cracking, and porosity. Fiberglas impregnated coverings have not been satisfactory. Consideration has been given to covering with a thin titanium sheet cover and with ordinary wood or polyester impregnated wood covers. The titanium should be ideal but expensive to install. The wood, especially when impregnated with a polyester resin, should give good service life.

There have been explosions in retention towers. In one case, at least, it is thought that the failure was due to loss of temperature control due to corrosion on a 317 stainless thermowell.

There has been attack on chlorine dioxide stock washers. In most cases these are constructed of 317 stainless steel. In some installations, the chests are of ceramic tile. The 317 stainless pits and rusts where pulp adheres to the surface and is not removed. There are many instances where the washer wires are severely pitted and attacked. In some washers, the notched bars have been attacked. The pH of the liquor apparently has a great deal to do with the rate of attack. In some mills the solution is buffered to a pH of 8 and lines and washers in 317 stainless have given good service whereas at pH 7, there was attack. In other cases, buffering to 6.0–6.5 pH has been adequate. It was stated that by pH control, a Swedish mill had increased washer wire life from 3 to 5 years and that they expected by further control of pH to get 10 years' life.

The condition of the stainless 317 is important in securing good service life. The metal must be free from carbide precipitation which will cause extremely rapid attack. It is also felt that the metal composition should be considered and that the chemistry should be kept on the high side, especially in nickel and molybdenum.

The question was raised as to the proper temper for washer deck wire. It is known that fully annealed wire will stretch in wrapping and more while in operation. This bulging does cause trouble. There were no definite answers from the interested parties in the audience as to whether 1/4, 1/2, or full hard wire should be employed. It is felt that the wire should be drawn hard enough to prevent subsequent "growing" but no harder than necessary. This might be in the range of 1/4 to 1/2 hard.

White water and dilution lines from the chlorine dioxide stock washers have given trouble. 317 stainless steel has failed due to perforation. Some trouble has developed at or near welds where pulp, scale, etc., hang up. The products of corrosion tend to precipitate or run down the pipe wall and form rusty, heavy tubercles. Pictures were shown of tubercles 1/2 to 1 in. high within the 317 lines. Where the 317 stainless surface is kept clean, the surface appears to be intact. It is apparent here again that pH is an important factor. It was reported that trouble developed in a 317 line at a pH of 7.0 and was corrected by raising to pH 8.0 with caustic.

Some rigid PVC pipe has been installed and has given satisfaction for the several years it has been in service. Fiberglass-polyester laminate pipes has not been too satisfactory. It was the opinion that this has been due to the method of manufacture and possibly to the resin formulation. There were representatives of two plastic pipe fabricating companies present who discussed the problems involved in making large size, up to 20 in. diam., in polyester-impregnated fiberglass pipe and flanges. They will take this matter under advisement and write to the subcommittee chairman, R. E. L. Wheless, giving him their ideas on what could be done to improve quality, set up specifications for the large diameter pipe, and to advise on strength-temperature limits. The Corrosion Committee members will be advised on the outcome of these reports.

Regarding the use of flanged joints on plastic or plastic-glass laminate piping, it was recommended that flanges be eliminated where possible in favor of butt joints with fiber glass-impregnate wrappings.

Questions were raised on attack on 316 and 317 stainless deck wire on chlorination washers. This is an irregular attack. In some instances it has occurred where the wire and notched rods were sensitized and the attack was due to carbide precipitation and intergranular attack. In other cases, it has appeared to be due to attack on inclusions in the stainless steel. In many cases, the wire operates with no difficulty.

The use of catalyzed epoxies in caustic and chlorine dioxide environments to protect concrete and structural steel was discussed. In some cases, structural steel in bleach areas has been protected for 5 years with catalyzed epoxies with the coatings and metal still in good condition. In some cases, especially on floors, epoxies with sand have been used successfully. The important factor in surface protection, however, is the surface preparation before painting.

SARAN and PVC lined steel pipe have been used for handling hypochlorite solutions. Titanium would be ideal for this service but expensive. Type 316 stainless should be satisfactory for sodium hypochlorite service with an excess of caustic present.

The meeting did bring out the fact that corrosion is a major problem in pulp bleaching. The discussions also emphasized the fact that actual operating conditions where corrosion develops should be determined. When good and bad results on materials of construction are tabulated together with actual detailed operating conditions as to temperature, chemicals present, pH, velocities, abrasion, cavitation, aeration, etc., real worth-while advice can be offered.

E. W. Hopper, *Chairman*

Drying Committee

The meeting was called to order at 10:45 a.m., May 26, 1960, at the Research Building, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., by S. G. Holt, chairman. The minutes of the previous meeting were approved.

1. Progress on items from previous meeting minutes. Joe Killian is to follow up and seek information with regard to the suggestion by Fred Perry that Dr. Nissan be requested to present the paper that he had presented at a recent A.I.Ch.E. meeting in San Francisco.

2. The following schedule has been made up for the Drying Committee activities at the 15th TAPPI Engineering Division Conference, Jacksonville, Fla.

Tuesday, Oct. 25, 1960—9 a.m. to 12 noon—Drying High Velocity Air Drying
Wednesday, Oct. 26, 1960—9 a.m. to 12 noon—Drying Radiant Heat Drying

R. C. Swaney will be the moderator for the Radiant Heat Session and S. G. Holt will moderate the High Velocity Air Session.

The speakers for the Radiant Heat Drying Session will consist of:

E. S. Mack, Manufacturers Representative, Asheville, N. C.
F. J. Prince, Manager Sales Engineering, Perfection Division of Hupp Corp.
O. Wagner, Manufacturers Representative, Perfection Division of Hupp Corp.

The technical introduction to radiant and infrared energy will be covered by Mr. Prince and the more practical aspects of the application of this energy as related to the paper industry will be covered by Mr. Wagner and Mr. Mack.

Three hundred and fifty copies of the paper will be printed by the American Gas Association.

Use of High Velocity Air Impingement in Drying—The speakers for this session will consist of: Part I

1. Claes Allander, Swedish Flakt Co., "Fundamentals of Impingement Air Drying." The abstract of this paper has been received.
2. Robert Daane and S. T. Han, "Analysis of Air-Impingement Drying." The abstract of this paper has been received.

The Part II of this session would consist of a user's panel discussion moderated by S. G. Holt. The following people are already lined up for the panel membership.

Joseph Killian, West Virginia Pulp & Paper Co., Luke, Md.
Philip Murphy, Crane Co., Dalton, Mass.

Three more members will be lined up soon.

It was decided that the secretary send return addressed postcards to Drying Committee members to submit questions on air drying that they would like the authors to elaborate on. S. G. Holt will send the submitted list of questions to Casper Swaney for transmittal to the authors.

H. O. Teeple requested that TAPPI would like to have, for the program announcement, all speakers' names, company association and titles of papers, at an early date. He is to send copies of "Author Manuals" to Swaney, Holt, and Khandelwal for distribution to the authors.

3. *Project 5C5—Drying Rates of High Pressure Driers.* No report on this project. L. G. Janett will be asked for an early report on the high pressure drier survey. This report will be presented by title only and published in TAPPI, if ready, by October, 1960.

4. *Project 757, All Radiant Heating Methods.* The preceding title is to be adapted now and is changed from "Radiant Heating." The reorganized subcommittee will be as follows: R. C. Swaney, chairman; L. R. Vianey, L. Blomgren, W. A. Green.

Mr. Vianey reported that he wrote inquiries to 15 companies and all of them wrote acknowledgments, but only one company was applying electrical infrared to paper drying. The name of this company is Infrared Systems, Inc., Box 1, Pompton Lakes, N. J. They may make information available for prospective customers.

5. *Project 759 Gas Turbines.* This project should be reviewed in 1961.

6. *New Project, Moisture Sampling.* The subcommittee chairman is Don Pohlman assisted by Garo Krikorian and Nick Reitzel. A new project proposal has been written and a request for a Project Number has been sent to M. J. Osborn.

Mr. Pohlman was unable to attend this meeting and wrote a letter questioning TAPPI Data sheet No. 155 on Paper Machine Drying Rates.

"Another point which should be brought up at this meeting concerns Data Sheet 155 on Paper Machine Drying Rates. This information is essentially correct when working to 95% moisture-free paper. However, when working with Yankee drier rates to say 70% moisture-free at the creping doctor, the information given is entirely wrong. A number of people I know have used this data sheet for Yankee drying and I suppose there are many others. Horace Fishwick and I have discussed this problem and he can enlighten you more.

The whole problem lies with *M* (the pounds of water evaporated per pound of paper as dried). The paper as dried at the reel is 95% fiber but the paper as dried at the creping doctor may be only 70% fiber."

It was the opinion of all present that a subcommittee be appointed to look into this data sheet. Messrs. Fishwick and Janett were nominated to form a temporary subcommittee to look into Data Sheet No. 155. Mr. Teeple stated that if No. 155 sheet is composed of a multiple of subjects then a revision should be made to divide it into separate data sheets.

7. General Subjects.

(a) Chairman Holt received a letter from Chairman J. V. Cundelan of Paper Mill Drive Requirement Subcommittee requesting data on Power Requirements for High Velocity Air Driers. The drive horsepower is of interest to them. A. J. Cirrito and J. J. Killian were appointed a subcommittee. Killian will accumulate the available data and send it to Mr. Cundelan.

(b) Committee Attendance. Mr. Holt is to make a chart of committee meeting attendance and write letters regarding attendance.

(c) Howard Stevens submitted his resignation from the Drying Committee which was accepted with regret.

(d) The meeting was adjourned at 2:30 p.m.

K. K. KHANDELWAL, *Secretary*

Pulp Manufacture Division

Mechanical Pulping Committee

A meeting was held in the Conway Hotel Pioneer Room, Appleton, Wis., on May 19, 1960, at 10:00 a.m. T. F. LaHaise, first vice-chairman, presided over the meeting in the absence of S. R. Parsons, who had suffered a back injury. Mr. LaHaise opened the meeting with a welcome to the new members and alternates.

The secretary was directed to read the minutes of the last meeting, Feb. 22, 1960, which were accepted as read with this exception:

CORRECTION

Project 779. When this project was instituted, the title as it appeared in the minutes was apropos, but as time went on and the committee developed this subject, it no longer fit into the category of the manual. Its present scope includes the study of the various processes of mechanical pulping and as such requires a more descriptive title. This project should be further corrected to state that Joseph Blinka is chairman in place of J. H. White, as previously stated. Mr. Blinka will retitle the project and so report to Chairman S. R. Parsons.

Mr. Blinka submitted an interim report on this subject which is as follows:

"*Groundwood Interim Report 1959*

"Continued interest in the 'refiner' technique for groundwood-making was in evidence during 1959, however, as much or more interest in the historic pulpstone process was shown.

"An attempt at a theoretical approach to historical groundwood-making was made with no real success. Wood structure was found to be an important rate and particle size determining factor (*1*). In other studies (*2, 3*), wood angle relative to the face of the stone was found to affect freeness, not pulp strength or power usage.

"Groundwood-making has been extended to other woods. Southwestern low density thin-walled pines have been found to yield newsprint quality groundwood (*4*). European poplar has been found to give a low strength–high bulk pulp. Strength is increased greatly through chemical pretreatments (*5*). Birch groundwood suitable for board manufacture is made from sodium sulfite-sodium bicarbonate impregnated chips (*6*). Sawmill wastes can be converted to a low tensile pulp. Tensile may be improved through preimpregnation with sodium sulfite or sodium hydroxide (*7*). Australian eucalyptus chips impregnated with cold caustic give a newsprint quality pulp (*8*).

"Chemical pretreatments of logs or chips greatly extend th raw material supply for groundwood and, in addition, make possible considerable improvements in tensile and freeness. Addition of sulfite or bisulfite to water added to the face of a pulpstone reduces power requirements and gives a brighter, higher strength pulp (*9*).

"Mechanical modifications or additions to the historic process include micrometer sharpening of the stones for quality control (*10*), coarse grinding followed by refining to increase capacity as much as 100% (no change in power required per unit of pulp) (*11*), a new type 'pulpstone' made by fastening abrasive elements to the surface of a metal cylinder (*12*), and the use of a number of horizontally mounted grinder wheels to wear away a rotating log passing beneath them (*13*).

"In summary, groundwood today (*1*) can be made from almost any wood source with the help of chemical preimpregnation, (*2*) can be made using a variety of attrition type processes ranging from the conventional pulpstone to a disk refiner, and (*3*) can be made over an extreme quality range starting at conventional strength and freeness to the very high strength–freeness range in the chemical pulp direction."

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Liaison Activities

J. H. Perry brought to the attention of the committee the fact that some time in the past it was considered beneficial to the committee to have a Canadian member and for a time W. H. de Montmorency served on both the Canadian Mechanical Pulping Committee and this one.

J. K. Kirkpatrick, as liaison officer, will correspond with the Canadian Committee in regard to this point. It was suggested that one approach to this might be that an invitation to the Canadian Committee be extended for our committee meetings which would permit any or all of the Canadian personnel to attend. The Canadian Committee would extend a similar invitation for their meetings. Under this arrangement the burden would not fall on any one individual but would enable anyone most conveniently located to attend Mechanical Pulping Committee meetings.

A. A. Yankowski and J. H. Perry were asked to approach the members of the West Coast Mechanical Pulping Committee with the object of inviting any or all of their members to serve with our committee.

Memberships

A motion was made by J. K. Kirkpatrick, seconded by A. A. Yankowski and carried, that a study be made of the advisability of having suppliers as members of our committee. This is a function of the first vice-chairman, T. F. LaHaise; therefore he appointed a committee consisting of Joe Blinka, Maung Htoo, and Tony Yankowski to serve with him in this study.

TAPPI

It was the feeling of the Committee that a member of TAPPI headquarters in attendance at the meetings was most helpful and it was suggested that someone from headquarters be present at future meetings.

Projects

Project No. 680—A Survey of Groundwood Mill Process Instrumentation, J. K. Kirkpatrick, chairman. J. K. Kirkpatrick reports that his subcommittee has the approval of the Chairman of the Engineering Division of TAPPI and will receive help from the TAPPI Instrumentation Committee for the preparation of a questionnaire to be submitted to the industry. This questionnaire to be circulated to determine the degree of instrumentation in the Mechanical Pulping Industry and to solicit further information in regard to more instrumentation. The questionnaire will be of the check-off type.

Project No. 793—Fourth International Mechanical Pulping Conference—1961. It was reported that plans were well under way for the forthcoming International Conference and it was suggested that any or all members of this committee should make some effort to attend the meeting June 17 at the Edgewater Beach Hotel, Chicago.

New Business

Election, Second Vice-Chairman. The names of several people were submitted in nomination by the committee and these in turn were voted upon with the result that Joseph Blinka was elected second vice-chairman.

The secretary was directed to send a copy of the minutes of March 8, 1957, to Mr. Blinka. These minutes outline the duties of the officers.

New Projects

A. A. Yankowski suggested that a study of mechanical pulping testing be undertaken with the object of determining the most effective methods. Maung Htoo suggests that well-known people in the industry be invited to attend our meetings where they would be expected to express their thoughts regarding testing.

A. A. Yankowski was appointed chairman of the subcommittee to pursue this subject. He in turn requested that Maung Htoo, Earl Schafer, Earl Johnson, and N. Sanger serve with him on this committee.

This project will be entitled, "Better Methods of Mechanical Pulping Evaluation," and should be assigned a project number. It was advocated that a subcommittee be formed to represent the groundwood insulating board phase of mechanical pulping.

A motion was made by J. K. Kirkpatrick, seconded by Joe Blinka and carried, that TAPPI headquarters be asked to publicize the mechanical pulping manual, Monograph No. 21, to acquaint the industry with its availability and its usefulness as a manual for mill operators.

The acting chairman, Mr. LaHaise, thanked the committee members for attending, in particular the alternates, Gil Godin, E. H. Madison, and N. Sanger, who made several valuable suggestions.

The next meeting will be held possibly in September, the definite time and location to be decided by the Chairman.

There being no further business, the meeting was adjourned at 5:00 p.m.

The committee as a group gratefully accepted the invitation of Mr. Yankowski to visit the Kimberly mills of Kimberly-Clark Corp., on May 20. Additional transportation was provided and able guides were assigned to conduct the Committeemen through the mill.

J. H. Perry, *Secretary*

Pulp Purification Committee

The Pulp Purification Committee met at the Edgewater Beach Hotel in Chicago on June 13, 1960. Chairman Kraft opened the meeting at two o'clock with a welcome for the new committee members: W. D. Rice, G. E. VanGoethem, and F. A. Simmonds. The minutes of the preceding committee meeting were read by the Secretary and approved by a voice vote.

R. J. Auchter, program chairman for the Pulp Bleaching Conference, discussed procedures for the conference. Every effort would be made to have the sessions start punctually and the committee members were asked to help make this possible. The scheduled papers for a given session were all to be presented before the discussion period. Paper slips were to be provided at each seat with additional supplies available from floor assistants so that questions raised during the presentations could be recorded for the discussion period. In the discussion period, the authors were to answer the written questions directed to them first. Oral questions from the floor were to be received after the written questions were handled. Four committee members were to act as floor assistants during each session. They were to collect questions and handle floating microphones during the discussion period. A permanent record of each of the discussions was to be made by means of a tape recorder. Only the panel discussion on Thursday is to be published. An authors' breakfast was arranged for each morning at which the authors could meet with the moderator, the projectionists, and the floor assistants. This was designed to help work out any last minute production details.

1961 Annual Convention

Chairman Kraft pointed out that it might not be possible to complete all the discussion from the Pulp Bleaching Conference in the allotted time. He suggested a half-day panel discussion at the next annual convention. This would take care of any unanswered questions and would provide means for handling questions which may be conceived after the conference is completed. This plan received support from Howard Rapson and Dick Auchter. A question was raised on whether the panel should be selected to provide for a technical or operational representation. Herb Teeple recommended that a questionnaire be mailed to those attending the

conference to determine their preference in the matter. Replies to the questionnaire could be tabulated and made available so that a decision could be made by September 1st. This would permit announcement of the panel composition in *Tappi*. A motion was made and approved that the type of panel to be organized for the Annual Meeting be based on the results obtained from the questionnaire. If enough papers are available, a Pulp Purification Session will also be set up for the February meeting, as usual.

Next Pulp Purification Conference

No decision was made on definite plans for the next Pulp Purification Conference. However, the opinion was expressed that this should be planned for 1962 or 1963. Dick Auchter stated that plans for the next conference should get under way much earlier than was the case for this first conference. The next conference chairman should clarify registration situation in regard to authors. No action was taken on this point.

Research Project No. 154

W. H. Rapson reviewed the purpose of this project and introduced I. H. Spinner, who has been conducting the literature research and evaluation. Mr. Spinner stated that one or two months may be required to finish the work exclusive of typing. He then gave a brief review of problems encountered and the type of information which will become available. No references of work have been found on the effect of fillers or additives on color reversion. Work done in the last five years on cotton linters has been found to be most revealing on causes of color reversion.

There was some discussion on the use of the Spinner report. The discussion may be summarized along three possible lines of action:

1. A monograph-type publication by TAPPI for general distribution to members.
2. A low-cost report with limited distribution.
3. Inclusion in the Pulp Bleaching Monograph.

The final decision on the use of this report was deferred until the February, 1961, meeting of the committee.

Pulp Bleaching Monograph

Mr. Rapson reported that the initial drafts of ten chapters had been received. The balance were expected soon. If these missing chapters are not received in the near future, the September date for return of manuscripts to the authors will not be achieved. The target date for the completed and revised manuscripts is the end of this year. Spring of 1961 now appears to be the most likely publication date.

Mr. Doane recommended that careful attention be paid to the details of production of the book. This includes choice of paper, type, and method of presenting illustrations. Mr. Teeple felt the book should not be cheapened by reducing the number of drawings or figures. There was general agreement with these objectives although no specific action was taken.

Meeting adjourned at 3:40 p.m.

L. B. Taylor, *Secretary*

Testing Division

Adhesives Testing Committee

The meeting opened at 10 a.m., May 18, 1960, at the TAPPI Headquarters, New York, N. Y. Minutes of the Feb. 22–23 meetings, as published by the secretary, were accepted.

All present joined in congratulating Mr. Sams on his monograph chapter on silicates, and in their admiration for the promptness and thoroughness of his work.

Mr. Neuss reviewed the past three years during which time the committee held twelve meetings, and heard talks by fifteen of the leaders in the field of adhesives. In spite of this, attendance has been very poor. Suggestions to increase attendance and make better use of the speakers were: to concentrate them on the Annual Meeting and one other; to publish the talks in a yearbook, or in magazines; to spread responsibility and a feeling of usefulness among a larger group of members. Mr. Neuss will contact all members to discover their current status and interest in committee work. Subcommittees were established with the following volunteers to head them: professional contacts: Neuss; membership: Shirley; activities: Psyras.

Mr. Green moved that the Activities Committee explore the possibility of publishing condensed minutes of our meetings in *Adhesives Age*.

Mr. Sederlund reviewed the excellent work done in the early days of the committee, when a program of Routine Control Methods development and Mr. Faunce compiled and arranged previously published adhesion tests from Government Specifications, ASTM, TAPPI, etc. Copies of this 40-page compilation are available for those newer members who have not seen it. Three RCM's were published before work on the Monograph took precedence.

Mr. Faunce suggests that two of the four meetings should be devoted to furthering this work, and to cooperative writing and editing of the Monograph.

Mr. Richards delivered a talk on nondestructive testing based on the principle that heat transfers more readily through a good bond than through a poor one or a "skip." A sensitive heat detector can be used to record differences in heat transfer through a laminated web passing over a hot roller. Such an instrument is Radiation Electronic Co.'s "Thermodot" radiation thermometer, which measures and records infrared radiation at distances of 4 ft. and over, has a sensitivity of 0.01 °C., and a possible speed of 0.001 sec. It has been used on plastic laminates and rubber to metal bonds.

Monograph. Mr. Neuss is continuing his work on tack. Mr. Faunce submitted an outline of the uses of foil adhesives, and the end products in which they occur. Mr. Psyras submitted a brief outline on solvent adhesives.

New Business. Mr. Faunce presented the Hinde and Dauch pin test for corrugated board for consideration as a Routine Control Method. Although based on the same principle as RC-269, it was considered to be in wide enough use, and sufficiently different, to warrant publication as a separate method.

Next Meeting. Wednesday, September 21, at TAPPI Headquarters in New York. It will be devoted to work on the Monograph, and arrangements for the subsequent meeting.

The meeting adjourned at 4:00 p.m.

Fillers and Pigments Committee

The meeting was called into session at 9:30 a.m., Feb. 22, 1960, in New York, N. Y., with 14 members and visitors present. The minutes of the last meeting at Portland, Ore., Aug. 18, 1959, were accepted as read.

The following projects were reported as completed and will be sent to the committee members for letter balloting, when submitted.

No. 699, Analysis of Calcium Carbonate—George Hall.
No. 701, Analysis of Diatomaceous Earth—Herbert Dranich.
No. 702, Analysis of Calcium and Other Synthetic Silicates—Nathan Millman.
Part of *No. 705* correlation of Test Methods. Sampling for White Fillers and Pigments—W. H. Kreiling.

The status of other projects assigned to committee members follows:

No. 700, Analysis of Talc—Maurice Warner—No report.

No. 704, Methods for Slurry Viscosity, Enzyme Compatibility, Adhesive Demands, etc.—Paul Plante. The chairman suggested that Bill Kreiling contact Paul Plante to check on status and how he is planning to handle his project. It was suggested that he organize a task group. A proposed procedure for measuring viscosity of coating-pigment slurries sub-

mitted by Yas Nomiyama for Paul Plante at the Oregon meeting is attached for comments.

No. 705, Correlation of Test Methods for Various White Fillers and Pigments—William H. Kreiling. The chairman suggested that Bill Kreiling review ballot replies on methods for brightness, moisture, pH, and grit with reference to comments on these properties given at the Oregon meeting. The proposed method for sampling will be sent out for letter ballot.

No. 738, Testing of Colored Pigments—Harold Brill. Harold Brill reviewed some of the questions which arise in drafting a method for colored pigments, such as "when is a product a dye and when a pigment." For example, ultramarine blue and phthalocyanine blues are considered pigments and he suggested that trade usage should determine whether a product is a dye or a pigment. Normally pigments are considered markedly better in light fastness than dyes.

It was suggested that Harold Brill set up a task group and draft a survey of information to discuss with pigment producers and that he should have the consensus of industry before proposing method to the committee.

No. 646, Brightness of Clay—C. G. Albert. As recommended by Gerry Albert at the Oregon meeting, it was suggested that he submit his method to Jack Gunning as a proposed Routine Control Method, with copies to Stan Batruk and Bill Willets.

Miscellaneous. Keith Williams, vice-chairman, TAPPI Testing Division, mentioned that the Chemical and Optical Committees should get copies of methods we are proposing which may be of interest to them. Bill Willets proposed consideration of a new chairman for the Fillers and Pigments Committee which received a silent negative vote.

The chairman reported on the ASTM Conference on Pigments and noted no new committee would be formed for this purpose which would continue under ASTM Committee D1 on Paint, etc.

The next meeting of the Fillers and Pigments Committee is planned at the fall Testing Conference, September 26, at Grand Rapids, Mich. Notice of the meeting and an agenda will be sent to all committee members.

The meeting adjourned at 11:30 a.m.

S. J. Batruck, Jr., *Secretary*

Viscosity of Coating—Pigment Slurry

The viscosity of pigment slurries is important to the paper coater when it can be interpreted into performance in the final coating mixture. With some tendency evidenced by the industry toward increased slurry storage of pigments, the viscosity of slurries at high solids becomes more critical. Slurries must be agitated, pumped, and screened which require flow characteristics compatible to the system used. When the pigments are received in the dry form, the ease of make down of the pigment slip may be reflected by its viscosity at the required solids.

In considering the storage in slurried form one must first determine the maximum practical solids to give operable viscosities as well as conditions such as dispersing agent, buffering agent, wetting agent, or other requirements.

Due to the variety of pigments possibly considered in this test method as well as the variety of per cent solids dictated by individual capacities or requirements, no attempt is made to designate a standard percentage of solids in this method. To designate a type of dispersant for general testing would not be practical in many instances since certain pigments are more efficiently dispersed by specific chemicals or combinations.

Among the possible dispersants which could be used are the following:

Tetrasodium pyrophosphate.
Sodium tripolyphosphate.
Sodium tetraphosphate.
Sodium acid pyrophosphate.
Sodium hexametapyrophosphate.

Tetrasodium pyrophosphate used in a clay slip, for example, gives a minimum viscosity at a lower dosage than the other four dispersants mentioned above. TSPP is more critical relative to overdosing, however, and care should be taken to approach its optimum in a determination with care. Because of its more critical nature, it was chosen here to exaggerate the optimum effects. In actual usage this critical nature of TSPP is not necessarily a desirable characteristic. Manufacturers recommendations on specific dispersants should usually be used and this method can be adapted to evaluate the performance of these recommendations.

Several types of laboratory mixing equipment were also considered. The use of high-speed mixers was considered to assist in obtaining optimum dispersion. However, in practice it was found to be difficult to obtain duplicate results due to thermal effects as well as mechanical breakdown of the integral parts of the mixer. Lower speed agitators of either a disk or paddle type can give excellent duplication in a practical manner. The action of agitation is more typical of industrial use and the times required are also similar to actual mill requirements.

Viscometers will usually be selected at the convenience of the individual mills or more probably standardized within a company. Brookfield, Stormer, MacMichael, etc., are generally considered as the principal low shear types.

Some laboratories are equipped with high shear viscometers which are usually used for research purposes. When possible, all initial work on pigment slurries should be accompanied by high shear viscometer investigations. For routine control, the Brookfield viscometer has been arbitrarily chosen. The variation in flow properties resulting from high shear effects are well known. Similar materials can be evaluated quality-wise with low shear instruments.

Apparatus

1. Brookfield Special four-speed viscometer, modified Model RVF, operating at 10, 20, 50, and 100 r.p.m.
2. Analytical balance sensitive to 0.1 μ.
3. Balance having a capacity of 2 kg.
4. Thermometer with a range of 0 to 220°F.
5. Slurry can 8 in. high and 4 in. diam.
6. $^1/_{18}$ hp. variable speed motor.
7. Disk, paddle, or propeller agitator.

Test Specimen

Sample should be obtained according to the sampling procedure described in TAPPI Standard T 645 m.

Procedure

For nonpredispersed pigments:

1. Determine the free water (moisture) of the pigment sample. T 645 m-54.
2. Weigh out the equivalent of 500 g. of dry pigment.
3. Measure 500 ml. of distilled water, less the free water in the pigment when significant, into the slurry can.
4. Weight out the equivalent of 0.1% TSPP (dry) based on dry pigment. Dissolve the dispersent with agitation in the slurry can.
5. With agitation gradually add the pigment to the water-dispersant solution until serious thickening appears to develop. Allow the slurry to agitate for an additional 10 min. If appreciable thinning out has occurred after this time another increment of pigment may be added until the thickening again becomes serious. Repeat the procedure until a stable slurry viscosity is obtained. Temperature of slurry for all viscosities should be 77 to 80°F. or 26 ± 1°C. Weigh the remaining unslurried pigment and calculate the per cent solids of the slurry. With easily slurried pigments additional sample may be required but again the same procedure can be followed.

Pulp Bleaching Committee, June 13, 1960, Edgewater Beach Hotel Chicago, Ill.: Standing—R. R. Kindron, Food Machinery and Chemical Corp.; J. D. Wethern, Riegel Paper Corp.; R. J. Auchter, Kimberly-Clark Corp.; J. F. Whalen, Combined Locks Paper Co.; H. O. Teeple, TAPPI. Seated—F. M. Ernest, Allied Chemical and Dye Corp.; G. E. VanGoethem, Packaging Corporation of America; H. C. Scribner, Electric Reduction Co. of Canada, Ltd.; L. B. Taylor, Columbia Southern Chemical Corp.; W. D. Rice, P. H. Glatfelter Co.; I. G. MacGugan, Wyandotte Chemical Corp.; I. H. Spinner, University of Toronto; W. H. Rapson, University of Toronto; M. Wayman, Sandwell International, Ltd.; F. A. Simmonds, Forest Products Laboratory; A. D. Harbin, Jr., Diamond Alkali Co.; J. M. Robinson, Champion Fiber Co.; F. L. Fennell, E. I. du Pont de Nemours & Co.; F. Kraft, Marathon, Ltd.; J. P. Hagan, Olin Mathieson Chemical Corp; K. A. Zachariasen, Buckeye Cellulose Corp.; H. G. Hopkins, Olin Mathieson Chemical Corp.

6. Add increments of the dispersant in 0.05% dry quantities based on dry pigment, and allow each addition to agitate an additional 10 min. to insure complete solution of the dispersant. Take viscosity readings at the end of each agitation period and continue until a minimum viscosity is reached followed by a gradual increase in viscosity with further additions of dispersant.

7. Report the quantity of dispersant required to obtain the minimum viscosity as the optimum dispersing agent level for the particular pigment at the calculated per cent solids. List also the viscosities at 10 and 100 r.p.m. giving the spindle number.

8. Further addition of pigment may then be made accompanied by the required increment of dispersant to equal the optimum dispersant level until a point is reached where the slurry viscosity is just short of the inoperable level.

9. Report the calculated solids at this point as the maximum operable per cent solids. Report also the Brookfield viscosities at 10 r.p.m. and 100 r.p.m. listing the spindle number used.

For predispersed pigments steps numbered 1, 2, 3, 6, 7, 8, and 9 will apply.

Comments should be sent to: Paul Plante, St. Regis Paper Co., Carthage, N. Y.

Pulping, Bleaching, and Papermaking Chemicals Testing Committee

The organizational meeting of the committee was held in the Hotel Commodore, New York City, on Feb. 22, 1960, beginning at 9:00 a.m. K. H. Williams, Chairman of the Nonfibrous Testing Committee, presided. The list of persons attending appears below.

The group suggested Herbert S. Hopkins as chairman and Mason Hayek as secretary. These nominations will be acted upon.

The object of the committee's efforts will be to revise old methods of testing chemicals for paper and to develop new test methods not previously reported in the TAPPI Standards. All chemicals may be considered except pigments, adhesives, and waxes. The latter three classes are covered by other committees in the Nonfibrous Testing Committee.

The areas of interest of the testing committees were previously established by the Steering Committee of the Testing Division.

Committee members suggested that the specific projects to be studied be selected by the individual members on the basis of their particular interests. It was suggested that a comprehensive list of chemicals in which the members are interested be prepared and circulated together with a list of the TAPPI testing methods. Several members are interested in specialty paper chemicals, rather than heavy chemicals.

K. H. Williams will provide a list of TAPPI standard methods that require revision. James R. West expressed an interest in methods for the analysis for sulfur. H. S. Hopkins will cover methods for chlorine dioxide.

The chairman will collect information from members about areas of interest and will distribute the necessary background information in the near future. He plans to enlarge the committee by contacting representatives of several companies which have not yet responded to the previous invitation to join the committee.

The meeting adjourned at approximately 10:30.

Mason Hayek, *Secretary*

Pulp Testing Committee

The meeting was called to order at 10:10 a.m. at the Hotel Commodore, New York City, Feb. 22, 1960, by Chairman Cousins. The minutes of the previous meeting were read by Secretary Rastatter, and approved as read.

The next meeting will be held in Grand Rapids, Mich., Sept. 27–29, 1960, in the Pantlind Hotel.

No. 132 Revision of T 200 M Lab Beater. There was no direct report from Subcommittee Chairman Curt Walseth. It was the opinion of those present that this standard needs revision, with more specifications on how the bed plate and beater bars are to be preserved. Perhaps the beater should be investigated to see if it is the ideal type of equipment to start with. Could it be modified to improve it and save the considerable investment in lab beaters? There seems to be little problem in maintaining the uniformity of operation of a single beater (Mr. Elsevier told of maintaining calibration over 6000 tests) but calibration with other similar beaters is a problem. Dr. Nadelman uses a stroboscope to exactly determine the revolutions per minute. Should the kind of water used in beating be specified? The general feeling of the group indicated that a small task force should be appointed to study these problems.

No. 448 Revision of T 213 M-43. Dirt in Pulp. The new method submitted by Dr. Clark was not being used among the mills represented. Electronic counters eliminate human error. The PPRIC counter (about $2500) is standardized against a master instrument in their lab. These counters are not too practical on clean pulp, and seem to count high where a preponderence of large dirt is present. These could not be made into a standard but are very useful for routine control.

Mr. Smith submitted a description of the method Mead uses in counting dirt. They count by transmitted light, specks over 0.04 sq. mm., on a dried sheet, 1.5 g., made on a 15-cm. filter paper in a Buchner funnel. They report number of specks per grain to the nearest 0.1.

Several present felt making sheets from the pulp introduced dirt. Most felt that bleached market pulp is now within the sensitivity of any test we now have.

No. 470, Pulp Consistency. Subcommittee Chairman Lyman Aldrich presented an excellent prepared method for determining pulp content of pulp-water mixtures. Methods for mixtures from 0 to 100% were proposed. It was suggested that this method be limited to slush pulps with a second

Pulp Testing Committee

Paper Shipping Sack Testing Committee

method to deal with noodle and fluff pulp, with a single drying method for all determinations. Comments dwelt on the use of dry air in ovens, errors in sampling, and the use of dilution. Mr. Aldrich will revise his suggested method.

No. 636, Testing High Freeness Pulps. This project is still at The Institute of Paper Chemistry. Chairman Cousins will appoint someone to pursue this and report at the September meeting.

No. 751, Second Round Robin Testing of Reference Pulp. The data from the second round-robin testing will be published. The pulp has changed. Mr. Brandon would like to see the pulp tested again with as many as 25 beaters to establish a new base line.

E. L. Rastatter, *Secretary*

Paper Shipping Sack Testing Committee

The TAPPI Paper Shipping Sack Testing Committee Meeting was held at the Hotel Commodore, New York City, 9:00 a.m., on Monday and Tuesday, Feb. 22 and 23, 1960.

The scope and objectives of the TAPPI Paper Shipping Sack Testing Committee were reviewed by Chairman K. A. Arnold, which he stated are as follows:

1. *Scope*—"Development and revision of testing methods specifically for shipping sack papers."
2. *Objectives*—The objectives of this Committee may be classified as (a) short-term test method projects, and (b) long-term development projects.

In regard to (a) short-term projects, the activities of the committee have included round-robin test programs simultaneously applied at several different laboratories covering a commonly used method for testing of paper. The purpose of such a program is to establish reproducibility of test methods and applicability to the shipping sack industry. As a result, modified test methods have been submitted to and approved by the Technical Association of the Pulp and Paper Industry. Projects under this classification would include "smoothness of flat shipping sack paper at 3 p.s.i. clamping pressure, procedure for dry tensile testing of shipping sack papers, procedure for wet tensile testing of wet-strength shipping sack papers." It is anticipated that such standardized test methods would eventually become referenced in Federal Specification UU-S-48c, Rule 40, Section 10(c) of the Uniform and Consolidated Freight Classifications, Rule 5, Section 8(a) of the National Motor Freight Classification and Packing Institute specifications.

In regard to (b) long-term projects, the committee regularly selects important paper characteristics which are not currently evaluated by TAPPI standard test methods and develops a new and suitable method. With this type project particular emphasis is placed upon correlation of such paper tests with filled bag performance. Examples of projects in this category include the suggested TAPPI method for "Tensile Energy Absorption of Paper," which is being developed to evaluate performance characteristics of extensible papers in particular and sack papers in general. A second example is the development of a test method for the coefficient of friction of sack papers. Such a test is required to indicate resistance of filled bags to slippage by a test applicable to the paper surface employed on the outside of the sack. This test must be suitable for comparison of coated, creped, and other sack papers treated especially to increase coefficient of friction.

The committee has been questioned regarding the connection between itself and the program on multiwall sack kraft evaluation at The Institute of Paper Chemistry. The major manufacturers of shipping sack kraft paper are sponsoring a long-term development program at the Institute. Objective: to provide a technical basis for evaluation at the end of the paper machine which will predict physical performance of the completed sack, assuming uniform quality of conversion. The current program includes:

1. Study of literature and member companies' experience in attempting the correlation among paper test results, laboratory sack strength evaluations (such as drop tests), and commercial shipping performance.
2. The conversion of representative commercial sack papers into sacks, evaluation of both paper and sack strength properties by currently known methods, the correlation of paper tests with bag test results. This phase includes trials with newly developed test instruments and techniques.
3. Evaluation of sacks from the laboratory program under commercial shipping conditions, and analysis of data to relate the field performance with laboratory tests. The ultimate objective of the overall study is to develop a simple laboratory test by which sack performance can be predicted.

It will be observed, Dr. Arnold said, that the Institute program complements the activities of this TAPPI Paper Shipping Sack Testing Committee.

The project to develop a Suggested Method for Tensile Energy Absorption of Paper (No. 769) is under control of the following Subcommittee of the TAPPI Paper Shipping Sack Testing Committee: H. S. Welsh, chairman, K. A. Arnold, M. L. Taylor, and D. M. Yost.

In the absence of H. S. Welsh, chairman of the subcommittee, K. A. Arnold advised that the proposed procedure has been accepted by the committee for use in the first of two round robins; that the first interlaboratory test is now under way; that Ted Lashof of the Bureau of Standards and TAPPI Precision Committee is assisting with this part of the project; that after the first round robin involving 12 laboratories and a small number of samples is complete, the procedure will be

extended and revised, if necessary, prior to an extended interlaboratory evaluation of the procedure.

It is understood that the finalized procedure may be available by the fall of 1960.

TAPPI Project No. 607—Development of a Procedure for Dry Tensile Testing of Shipping Sack Papers (1955)—has been under the jurisdiction of the following subcommittee: C. P. Spring, chairman, R. P. Anderson, and M. L. Taylor.

Chairman Arnold announced receipt of a letter dated Feb. 10, 1960, from Ted Lashof on the subject of T 404 m, proposed revision of TAPPI Standard T 404 m-50, which is under the jurisdiction of the Paper Testing Committee. He also quoted from a report by C. P. Spring, dated Feb. 19, 1960, as follows:

> "The work of this subcommittee on dry tensile strength testing can be considered complete. We feel that the new proposed T 404 TAPPI Standard in which 'the rate of operation of the tester shall be set so that the test will be completed in 20 ± 10 sec., except that for precise work the tests shall be completed in 20 ± 3 sec.,' should be satisfactory since a simple correlation can be set up between results obtained at the specified speed and those obtained at faster testing speeds."

He asked if those present were in accord with the Feb. 10, 1960, draft, and consensus was that this draft was satisfactory for the tensile breaking strength of shipping sack kraft; that the new proposed T 404 m TAPPI Standard in which "the rate of operation of the tester shall be set so that the test will be completed in 20 ± 10 sec., except that for precise work the tests shall be completed in 20 ± 3 sec.," should be satisfactory since a simple correlation can be set up between results obtained at the specified speed and those obtained at faster testing speeds.

Accordingly, it was agreed that Project No. 607 be considered complete.

Subcommittee responsible for Project No. 608–Procedure for Wet Tensile Testing of Wet-Strength Shipping Sack Papers (1956)—is as follows: W. L. Shoemaker, chairman, G. P. Heller, and R. P. Kessler.

Chairman Arnold advised that he had received a letter from W. L. Shoemaker, dated Feb. 9, 1960, pointing out that the TAPPI Paper Shipping Sack Testing Committee at their meeting in February, 1958, proposed that Project 608 be held in abeyance until John I. Thompson Co.'s report was received on the dry tensile study "Project No. 607," after which round robin tests would be initiated.

M. L. Taylor recommended that the subcommittee consider wet tensile testing as part of the dry tensile testing procedure which is under intensive study, and that the subcommittee direct its efforts to a standard method of wetting and blotting in preparation for wet tensile testing.

Accordingly, it was voted that the committee in charge of Project No. 608 submit a summary of their recommendations for other factors than tensile testing of wet-strength shipping sack kraft; that this summary be presented at the forthcoming TAPPI Testing Conference scheduled to be held in Grand Rapids, Mich., in September, 1960.

R. P. Anderson, chairman of Project No. 770—Measurement of Coefficient of Friction of Multiwall Sack Paper (1959)—read the following letter he had addressed to the committee on Jan. 25, 1960:

> "As a matter of information and since only one other member of the Committee was present at the Testing Conference in Portland, Ore., last summer, I wish to provide certain information for your files in preparation for a Committee Meeting during TAPPI Week.
>
> "The Committee Project Proposal Form as approved, establishes the following:
>
> "Project No. 770 (1959).
> "Project Title—Measurement of Coefficient of Friction of Shipping Sack Kraft.
> "Project Objective—To recommend a test method suitable for measuring coefficient of friction.
>
> "Outline of procedure to attain objective—
> (a) Determine types of friction testers available commercially.
> (b) Determine methods now being used for testing frictional resistance of multiwalls.
> (c) Discover experience of Committee members who have used testing methods now available.
> (d) Conduct round robin tests to evaluate current testing procedures.
>
> "Task Force—R. P. Anderson, chairman, A. R. Ewing, R. P. Kessler, and H. C. Martin
>
> "The following have accepted membership as representatives of other committees: D. W. Reid (Precision Committee), R. R. Chase (ASTM Committee D-6, Subcommittee III), K. A. Arnold (ASTM Committee D-6, Subcommittee III), and R. H. Tompkins (ASTM Committee D-6, Subcommittee III).
>
> "Objectives a, b, and partially c have been accomplished (Minutes of Meeting Feb. 25, 1959)."

Discussion followed with regard to test equipment available commercially and also "home-made."

The major concern was the development of procedures recommended for a round robin test such that Ted Lashof of the Precision Committee could detail the variables into a plan suitable for statistical analysis.

Mr. Anderson suggested that there be added to the February, 1959, list of testing apparatus the following:

> TMI No. 98-5 Slip and Friction Testing produced by Testing Machines, Inc., 72 Jericho Turnpike, Mineola, Long Island, N. Y.; approximate cost $385; maximum reading dial gage—rate of loading—variable—test area 5 × 5.

Chairman Anderson advised that he would discuss with M. L. Taylor the possibility of establishing an instrumentation study of friction testers at The Institute of Paper Chemistry through the APPA Program.

In reference to procedures for round robin testing, it was determined that Chairman Anderson would prepare a questionnaire which would provide necessary information; that he would consult with Ted Lashof and/or D. W. Reid, and also would request the Precision Committee to advise him of variables which should be covered.

Some of the variables, it was mentioned, should include types of paper to be tested, among which possibly PE coated samples would be considered, together with sample size, weight of paper and description of testing equipment; also the method of measuring paper surface, and questions related to machine direction or cross direction testing.

It was believed that a "dry run" test might be arranged before the TAPPI September 1960 Meeting, scheduled to be held in Grand Rapids, Mich., on September 27, and it was hoped that the subcommittee could convene one day earlier in order to enable it to report results effectively on September 27.

Since Dr. Arnold has served the committee as its chairman for about $2^1/_2$ years, he called for the election of a new chairman to take his place, and it was voted that M. L. Taylor be elected to serve as chairman of the TAPPI Paper Shipping Sack Testing Committee for the next two years; that Dr. Taylor announce his choice for election of vice-chairman to serve with him.

F. Pocta, *Secretary*

Fifteenth

Engineering Conference

Robert Meyer Hotel

Jacksonville, Fla.

Oct. 24–28 1960

Engineering Division Comment

Dear Mr. Osborne:

Your letter of April 8, 1960, requested comments and project suggestions for the Engineering Division of TAPPI.

It would appear to me that specific engineering projects for divisional activity can best be outlined by the engineers from the pulp and paper industry who constitute your organization. A representative group of such men certainly is better qualified in this regard than is a corporate management group.

We, and the rest of the pulp and paper industry, are concerned with a number of general problems with which the Engineering Division might render valuable service. These all involve the cost of doing business today and certainly they affect our ability to compete with other industries for capital and sales dollars.

1. High Cost of New Machinery and Equipment

This is a basic problem with every new piece of equipment we must purchase. We can do nothing to reduce labor rates at fabricators, however, the engineers can contribute in a major way by simplifying designs, fabricating techniques, maintenance requirements, etc. Every pulp and paper process should be analyzed and studied until all basic principles are understood clearly. Certainly we still have a long way to go in sheet forming, pressing, drying, screening, coating, creping, calendering, etc. When the basic or fundamental process variables are understood the engineers can usually develop less expensive process equipment. The engineer must be more cost conscious today than ever before. I think the Engineering Division should take a critical look at every process in the industry and ask itself the following questions:

a. What variables affect the process?
b. Is the relationship of all variables clearly understood?
c. Are all variables under control?
d. Can the design be simplified or improved to reduce costs of fabrication, operation, maintenance, etc.?

2. High Cost of Building Construction

This cost factor also seems to have gotten out of hand. Considerable progress is being made in certain parts of the country and in other industries but I wonder if these advances are being studied and exploited by the engineers of the pulp and paper industry.

3. Automation and Process Control

In this area I have the general impression that the industry is spending too much on instrumentation without achieving adequate control. Are we controlling the proper variables? Are we generating data of no value? I strongly suspect that our instrumentation costs could in many cases be cut in half without affecting process functionality at all. Engineers should be concerned with devising minimum instrumentation systems rather than maximum. It seems rather ridiculous to have almost as many men changing charts and maintaining instruments as we have operating our machines!

4. High Materials Handling Costs

Material handling costs are direct losses since no value is added to the product. Here is an excellent opportunity for the engineer to make a major contribution by eliminating manual labor and conserving building space. I think the Engineering Division could make a major contribution by studying every process from the woods to the shipping platform which involves the movement of material and its storage.

Of particular significance in this area are the high costs of wood handling.

5. Losses Due to Corrosion

Your committee on corrosion is apparently largely concerned with the matter of digester corrosion which is certainly a major cost area. However, I am sure that the losses the industry sustains from the corrosion of piping, fourdrinier wires, press rolls, exposed machine frames, building components, boiler tubes, condensate lines, screen plates, filters, Yankee driers, etc., are staggering. Too many of these are taken for granted because they are slow and in many cases hidden until failure.

With the current advances in plastics, new alloys, inhibitors, platings, ceramics, coatings, etc., these from corrosion should be under control.

Again, I suggest that the engineers study every process of the pulp and paper industry to determine the critical corrosion problems and to develop proper control techniques.

As in the case of instrumentation, I am convinced that engineers waste sizable sums of corporate capital by overdesign in many cases. Due to ignorance of the corrosion problem and the proper solution, many men specify the most expensive material available instead of seeking an adequate material. Many engineers think there is only one stainless steel; viz., type 316!

6. High Engineering Costs

It is a sad commentary indeed when already high equipment and building costs must be supplemented with 10 to 15% engineering costs. Why must every engineering job be of the *custom* variety? Certainly many engineering situations are repeated time after time and yet we seem to have no standard designs to apply to reduce our costs. Piping, foundations, building components, drives, housings, pumps, fans, etc., are examples of standard equipment on which a minimum of engineering should be required.

In this same category is our inability to obtain quick estimates on costs to install equipment. Perhaps your engineering data program can generate cost and capacity information which will permit the development of quick cost estimates of reasonable accuracy.

7. Defensive Costs

Today, industry, in general, is under pressure to provide more benefits for the workers and the community than in the years past. Such expenditures have little tendency to provide a monetary return; they are purely defensive in nature. In this category are such problems as the elimination or control of noise, the pollution of streams and other public bodies of water, the pollution of air with dust, smog, and odors control of paper dust in work areas, etc. Certainly there are many suitable projects for your engineers in this category.

8. Training

The Engineering Division can provide a real service to industry through the training of our engineers—particularly our new recruits. However, to be of value you must provide basic academic analyses and discussions of pulp and paper-

making processes as well as information on advances and developments in techniques. We do not have to attend conferences to get sales pitches from the suppliers!

In the foregoing discussion I have outlined a number of general engineering responsibilities with which the Engineering Division of TAPPI can be most helpful. I have emphasized the cost considerations for this is a basic management responsibility to its stockholders. It is also an area of weakness for many engineers who fail to think of an engineering project in terms of its justification and pay off. I have, in effect, suggested that each of your committees look at the entire pulp and paper industry, from timberlands to finished product, for areas of high cost. Set up projects in each area aimed at cost reduction. Study each process to develop an understanding of the pertinent variables. Present factual information on what others have done. Then any good engineer should be able to solve similar problems for his own company.

I hope that the general issues which I have outlined briefly can be expanded in detail by the appropriate groups within your division. It should not be difficult to develop many specific projects of vital interest to our industry if the cost reduction objective is kept in mind.

It has been a pleasure to comment on the program of the Engineering Division, and I shall watch your future activities with increased interest.

Very truly yours,

Paul C. Baldwin
Vice-President, Scott Paper Co.

Questions and Answers

Good engineering questions are solicited as well as answers or alternate answers to the published questions. Material should be sent to TAPPI Headquarters, marked for the attention of H. O. Teeple. The items contributed will be forwarded to the Question and Answer Committee for processing. If comments are to be contributed, please refer to the question number.

(1-9/60) *Question* (**Turbine Hunts**): **What is the cause of a turbine changing speed rapidly, or so-called "hunting?"**

(1.1-9/60) *Answer:* This is caused usually by friction or lost motion in the valve gears. Friction is the most common cause. With direct-connected valve gears the friction is usually found in the steam valve or in the governor parts. With driven gears, such as the hydraulic gear, friction is most likely to occur in the pilot valve which is moved by the governor in order to let oil pressure into the operating cylinder and move the valve gear. Too heavy a dashpot will give sufficient friction to cause hunting. There are many other causes of this trouble which cannot be explained in a brief manner.

Lost motion usually produces surges or shaky motions of the valve gear or changes in load. The method of locating these troubles is usually to disconnect part of the valve gear and move it by hand. Lost motion or friction can readily be located this way.

(2-9/60) *Question* (**Increasing Plant Capacity**): **Our 7000-kw. turbine bleeds steam at two points for heating feedwater to 325°F., but the fuel burning equipment can only produce enough steam to generate 6500 kw. Would decreasing the amount of steam bled to the feedwater heater, thus lowering feedwater temperature, provide enough additional steam to get the extra kilowatts?**

(2.1-9/60) *Answer:* Bleeder operation makes use of the latent heat of the steam extracted for feedwater heating, after partial expansion. This would be lost if allowed to expand to the condenser, and turbine output would probably fall off instead of going up. This practice is sometimes resorted to to carry emergency overloads, only, however, when ample boiler or hot-water storage is available. If the boiler has an economizer, station heat rate will rise as before, but boiler efficiency will be somewhat increased. Air preheaters, if not already installed, would probably increase the efficiency and capacity of your fuel-burning equipment sufficiently to carry the load, and possibly more cheaply than through a change in firing arrangements.

(3-9/60) *Question* (**Loss in Direct-Current Motor at Different Speeds**): **Is there any loss of power if the speed of a direct-current motor is changed from normal speed, by introducing resistance into either the field or armature circuit?**

(3.1-9/60) *Answer:* The power loss at different speeds in an adjustable-speed direct-current motor depends on the method of speed control. If the speed is controlled by varying the field strength, the efficiency will be approximately the same at all speeds, provided the current drawn by the machine remains constant. If the speed is regulated by means of a rheostat in the armature circuit, the power loss is equal to that absorbed in the rheostat. If the current is kept constant, the power loss is directly proportional to the voltage drop in the rheostat, and therefore to the drop in speed, since the latter is proportional to the voltage drop in the resistance.

(4-9/60) *Question* (**Sparking Oil Rings**): **We have noticed sparks similar to static sparks whenever the oil ring in the outboard bearing of our turbine-generator comes in contact with bearing metal. The bearing surface is coated with a hard chocolate-brown deposit having many deep pits extending into the metal itself. What causes the trouble?**

(4.1-9/60) *Answer:* The sparks probably are static. The rotor acts as a condenser, discharging at intervals. Oil film insulates rotor from ground at every point except where spark jumps. If this is the trouble, fit a brush to bear on the shaft or on a ring grounded to the shaft and ground the brush-holder to the machine frame. If insulators separate frame and bearing support or end bell, remove them or put in a jumper. Other possible causes are a ground in the field rotor, or stray currents in the bearing from a faulty yoke casting, improper arrangement of exit or series field conductors, or unequal pole strength. Also check insulation between commutator ring and generator shaft and between bearing pedestal and machine base.

Fifteenth

Engineering Conference

TAPPI

Robert Meyer Hotel, Jacksonville, Fla.

Oct. 24–28, 1960

RC 284. Use of the Ohio Boxboard Score Bend Tester

The purpose of this method is to outline the use of this tester so that optimum accuracy and precision may be obtained.

Apparatus

An Ohio Boxboard score bend tester.

Discussion

The Ohio Boxboard score bend tester measures:

1. The force required to set up a box for opening and filling.
2. The force required to bend flaps for closing and sealing.
3. The force required to bend body or vertical scores.
4. The degree of "springback" or fight exhibited by flap or body scores over a period of time, by using the "hold" switch.
5. Stiffness of the unscored board, so that a ratio of score stiffness to board stiffness may be obtained, indicating the effectiveness of the score in reducing board stiffness.

The forces are applied by a motor-driven platen, driven at a constant rate of speed and registered on an eye-level dynamometer dial. Up to 2000 g. of force can be registered on the standard scale. Flap or body score widths up to 8 $^1/_2$ in. can be accommodated. Opening force on cartons up to the king size soap cartons can be measured.

The instrument has been designed as a production control tool. Ruggedness and simplicity of operation are built-in features and measurements are easily made by regular production workers.

Setting Up the Tester

Place the tester on a table or platform so that the dynamometer dial is near eye-level, depending on whether the operator will be in a standing or sitting position. The tester should be approximately level, although this is not critical. Mounting holes have been provided for permanent mounting if desired.

The long V-shaped opening force jig will be found taped to the dynamometer support upright. The lower end of the cord of the score bend yoke will be attached to the bending plate quadrant. The metal yoke on the opposite end of the cord will be taped down for shipment. Remove tape wrapped around the bottom of the dynamometer rod and be certain that it moves freely.

Adjustments and Calibration

The instrument is carefully adjusted and calibrated before shipment and normally requires no attention other than to zero the dynamometer indicators as described in the above procedures.

The end point for the score bend test is set for 90°. If desired for special tests, the end point can be adjusted to a lesser angle by loosening the contact screw on the collar at the right of the test plate. The collar is rotated slightly until the contact screw operates the microswitch at the desired angle.

Operation for Score Bend Test

1. Suggested sample size is 6 in. wide where possible, with about 2 in. above and below the score being tested, if box dimensions permit. Sample dimensions are left to the discretion of the user, but it is desirable to use standard sample widths when possible, making possible direct comparison of results. If desired, the entire width of the score may be tested, up to the $8^1/_2$ in. maximum.
2. Adjust the dynamometer assembly about 3 in. below the top of the support, using the knurled hand knobs to lock it in position.
3. Connect the instrument to a power source and press the "up" button. The test assembly will move upward and stop automatically at the starting position for the score bend test.
4. Hook the metal score bend yoke over the pins set into the V-block at the bottom of the dynomometer shaft. With the rotating test plate in the vertical position and a slight amount of slack in the cord, adjust the black dynamometer hand until it is about four divisions to the right of zero. The adjusting screw is at the top of the dynamometer assembly. Turn the red indicator hand clockwise, using the knob in the center of the dial, until the small projection just touches the black indicator. The red indicator should not read zero. If not, adjust the black indicator as needed. Once this setting is made, no further adjustment is necessary as long as only score bend tests are being made. It is important that the zero adjustment be made with no pull on the dynamometer. Slack in the flap score cord can be most easily gotten by bending the flap score test plate forward slightly. The dynamometer assembly may also be adjusted up or down on its support column so that a slight amount of slack is maintained.
5. Position the sample behind the sample holding plate. The center of the score line should be parallel with the lower edge of the rotating bending plate. The sample will be held firmly in place by the spring pressure on the sample holding plate. The degree of pressure can be adjusted by screwing in or out the knob on each side, so that the sample is held firmly, yet the holding plate can be pulled back without undue force on the knob.

Note that the sample holding plate is slotted so that it can be moved about $^1/_4$ in. up or down. Normal procedure is to make score bend tests with this plate in the bottom position. This allows a small area of the board itself to enter into the test result.

6. With the sample in position press the "down" button. The test assembly will move downward and the sample will be bent to a 90° angle. The test assembly will then return automatically to the starting position. The score bending resistance, in grams, is read on the *outer* scale of the dynamometer as the indicators move counterclockwise around the dial. The red lazy hand will stop and remain at the point of maximum resistance developed during the test. The lazy hand is then returned to the zero position, using the knob in the center of the dial.
7. If so desired, the "hold" switch is put in the "off" position. This will hold the sample at the 90° angle and allow measurement of the "springback" or fight exhibited by the flap or body scores over a period of time. A suggested procedure would be to note the lazy hand reading when the 90° angle is reached, then allow 20 sec. to elapse and note the reading of the black indicator. The difference between the initial and 20-sec. readings is an indication of the resistance the score would exhibit during a 20-sec. packaging cycle.

The greater the difference between initial and final readings, the greater the "fight" of the score.

After making a "springback" test press the "up" button to return the test assembly to the starting position. If so desired, return the "hold" switch to the "on" position for automatic operation.

Operation for Opening Force Test

1. Remove the score bend test yoke from the V-block.
2. Rotate the test plate to its extreme backward position. Place the legs of the opening force jig into the corresponding holes in the bending plate.
3. Press the "down" button and allow the test assembly to move down until there is sufficient clearance between the opening force jig and the V-block to allow the flat sample carton to fit between them. Since there is a limit switch controlling the maximum upward travel of the test assembly it may be necessary for small cartons, to slide the dynamometer head down on the support column. This will allow the end point of the test to be reached before the test assembly is stopped automatically.
4. Adjust the black indicator to zero. Turn the red lazy hand counterclockwise so that it covers the black indicator and also reads zero.
5. Hold the flat sample in position so that its bottom edge rests in the opening force jig and the upper edge is inside the V of the dynamometer block.
6. Press the "up" button. The test assembly will move upward, compressing the carton. The indicator will move clockwise around the dial. At the end point of the test the carton will open up suddenly. Immediately press the "stop" button. Read the opening force in grams in the *inner* scale as indicated by the lazy hand.
7. Press the "down" button to return the test assembly to the starting position for the next test and return the lazy hand to zero.

Note: No automatic stop at the end point is provided for the opening force test. This is necessary to permit various carton sizes to be tested. Each size will have a different end point. The test column can be stopped at any time during any test by pressing the "stop" button.

General

In order to maintain uniformity of results among users of the instrument it is recommended that a standard sample width of 6 in. be used for score bend tests whenever possible, and that a 90° angle be used for the end point. If a different test width or angle is used these should be reported with the test results.

In addition to tests on folding cartons, the instrument can be used to measure score bend resistance of corrugated board. The limiting factor in this usage is the capacity of the dynamometer scale. The heavier grades of corrugated, or solid fiber, will have a score resistance greater than the 2000 g. capacity of the standard scale.

Note: Should replacement parts be needed contact Paper Industry Instruments, Inc., 3537 Lee Road, Cleveland 20, Ohio.

RC-285. Smoothness of Paper

The purpose of this method is to provide a uniform means of determining the smoothness of a sheet of paper with a Sheffield paper smoothness gage.

Equipment

The equipment necessary to perform this test consists of a Sheffield paper smoothness gage and an air supply of 60 to 135 p.s.i.

Preparing the Sample

Cut an 11 by 11 in. sample from the test specimen.

Operating Procedure

The paper sample, which can be as large as 11 by 11 in. is placed upon the smooth glass plate and the gaging head is lowered by means of a short handle so that it rests free on the paper sample. No pressure other than the accurately established weight of the gaging head is used. Air under a low pressure of $1^1/_2$ p.s.i. enters through the orifice in the upper gage head and fills the annular groove between the two lands. The air then escapes or leaks across the surface of the paper under the annular lands. The height of the float in the Precisionaire instrument indicates the rate of flow across the surface of the paper sample. The smoother the sample, the less will be the air flow, and the lower will be the float position.

The instrument covers a range from zero flow, such as when the gaging head is in contact with the glass plate, to a maximum roughness represented by less than 1 sec. on the currently used air leak scales. The readings on the Sheffield smoothness gage appear instantly as soon as the gaging head comes to rest on the paper sample, and will remain fixed as long as the sample remains in place. The readings are always practically instantaneous, regardless of the degree of smoothness.

Reporting

The notation systems currently in use for recording paper smoothness are based upon the time required for a fixed volume of air to leak across the surface of a standard paper sample. According to TAPPI Standard T 479 sm-48, a theoretical reading of zero seconds would mean "perfect roughness." A perfect or very smooth surface could not be read because the reading would be an infinite number of seconds.

The Sheffield system of notation has the perfectly smooth surface recorded as zero. Rougher surfaces are indicated by correspondingly larger whole numbers.

The units designated on the Sheffield scale represent the number of cubic centimeters of air per minute, which is flowing over one square inch of paper area, multiplied by ten.

Note: This instrument may be purchased from the Sheffield Corp., Dayton, 1, Ohio.

Tenth

Corrugated Containers

Conference

of the

Technical Association

of the

Pulp and Paper Industry

Royal York Hotel

Toronto, Ont.

Oct 10–13, 1960

LOCAL SECTION ACTIVITIES

Meeting Calendar

September, 1960

16–17 Southeastern Section, Roosevelt Hotel, Jacksonville, Fla. Dr. L. G. Stockman, Swedish Cellulose Industry Central Laboratory, speaker. Plant tour at Container Corp. of America, Fernandina.
19–20 Pacific Section, Seattle, Wash., Seminar. Dinner meeting also on the 19th.
22–23 Pacific Section, Portland, Ore., Seminar. Dinner meeting also on the 22nd.

October, 1960

7–8 New England Section, joint meeting with Connecticut Valley PIMA, Schine Inn, Chicopee, Mass.
11 Metropolitan District, Empire State Section, 465 Lexington Ave., New York, N. Y.
27 Delaware Valley Section, Engineers Club, Philadelphia, Pa. Panel on "Stock Cleaning."

November, 1960

9. Metropolitan District, Empire State Section, 465 Lexington Ave., New York, N. Y.
14 Eastern District, New England Section, Armand's Beacon Terrace, Framingham, Mass.
16 Pacific Section, Salem, Ore., "Modernization."
17 St. Louis Section, Le Chateau Restaurant, 10405 Clayton Rd., St. Louis County, Mo., "Recent Advances in the Packaging Field," by C. P. Olstad, Crown Zellerbach Corp.
18–19 Southeastern Section, Dinkler Plaza Hotel, Atlanta, Ga.

December, 1960

5 New England Section, Storrowton Tavern, West Springfield, Mass.
9 Delaware Valley Section, Engineers Club, Philadelphia, Pa., "Functional Coatings."
13 Metropolitan District, Empire State Section, 465 Lexington Ave., New York, N. Y.

January, 1961

9 Eastern District, New England Section, Armand's Beacon Terrace, Framingham, Mass.
10 Metropolitan District, Empire State Section, 465 Lexington Ave., New York, N. Y. "State of the Industry," W. R. Adams, St. Regis Paper Co., New York, N. Y.
17 Pacific Section, Tacoma, Wash., "Process and Quality Control Techniques."
20–21 Southeastern Section, Francis Marion Hotel, Charleston, S. C.
26 Delaware Valley Section, Engineers Club, Philadelphia, Pa., "Packaging."

March, 1961

13 Eastern District, New England Section, Armand's Beacon Terrace, Framingham, Mass.
14 Metropolitan District, Empire State Section, 465 Lexington Ave., New York, N. Y.
21 Pacific Section, Longview, Wash., Shibley Award Meeting.
24–25 Southeastern Section, Bon Air Hotel, Augusta, Ga. Tour of Continental Can Co.

April, 1961

10 New England Section, Storrowton Tavern, West Springfield, Mass., Management Night.
11 Metropolitan District, Empire State Section, 465 Lexington Ave., New York, N. Y.

May, 1961

4–6 Pacific Section, Harrison Hot Springs, Tri-Way Convention.
19 Metropolitan District, Empire State Section, Ladies Night.
19–20 Southeastern Section, General Oglethorpe Hotel, Savannah, Ga.

June, 1961

8–10 Empire State Section, Whiteface Inn, Whiteface, N. Y.
9–10 Joint Meeting, New England Section and Maine–New Hampshire Section, Wentworth-by-the-Sea, N. H.

June, 1962

1–2 New England Section, Chatham Bars Inn, Chatham, Mass.
7–9 Empire State Section, Whiteface Inn, Whiteface, N. Y.

June, 1963

6–8 Empire State Section, Whiteface Inn, Whiteface, N. Y.

June, 1964

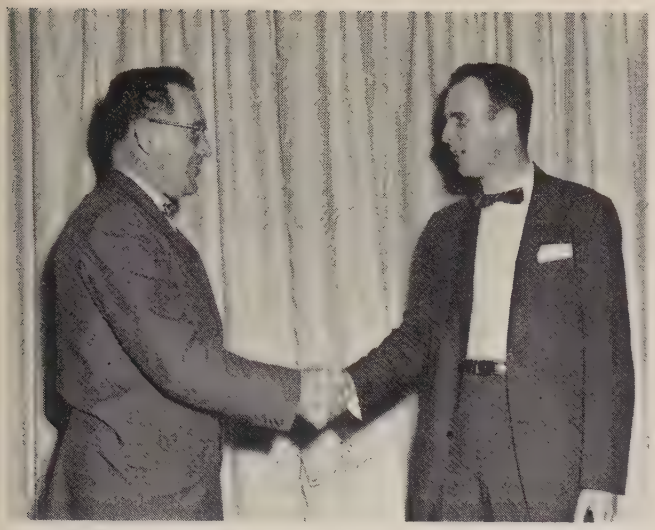
11–13 Empire State Section, Whiteface Inn, Whiteface, N. Y.

Delaware Valley

The Delaware Valley Section concluded its 1959–1960 season on May 27, 1960, with an open house meeting at the Beloit Eastern Corp. in Downingtown, Pa. During the afternoon, section members and guests had the privilege of touring the Beloit Eastern facilities, including the machine shop, roll shop, erecting room, and foundry. Of particular interest were the highly automated machine tools used to manufacture intricate metal parts for papermaking machinery. On display during the tour were winders, upper-calenders, roll wrappers, slitters, drives, and other papermaking equipment in various stages of completion.

Following the tour a social hour and dinner were held at the George Washington Motel in nearby Valley Forge, Pa.

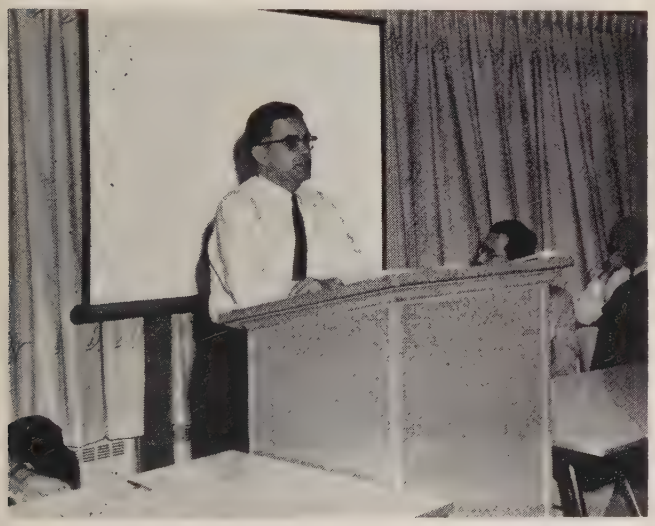
After dinner, Section Chairman George Boger called for Ralph Green, chairman of the Teller's Committee, to an-



Alfred L. Szirdon, 1960–1961 Delaware Valley chairman and Mr. George K. Boger, Jr., 1959–1960 chairman

nounce the results of the election for 1960–1961 section officers. Elected were:

Chairman—Alfred L. Saindon, Curtis Paper Co.
1st Vice-chairman—C. A. Wynn, Jr., Container Corp. of America
2nd Vice-chairman—H. L. Smaine, P. H. Glatfelter Co.
Treasurer—Thomas P. Czepiel, Scott Paper Co.
Secretary—Philip A. Cerasoli, W. C. Hamilton & Sons



W. D. Markowski, Beloit Eastern Corp., discussing windows at the Delaware Valley meeting

Mr. Saindon, on behalf of the entire Delaware Valley Section, expressed sincere thanks to Mr. Boger for his outstanding service to the section for the past 5 years.

Feature speaker for the evening was W. D. Markowski, manager of winder sales at Beloit Eastern Corp., who discussed machine winders with the aid of a number of slides.

The meeting was concluded with a unanimous vote of thanks to Mr. Markowski for his presentation and to Beloit Eastern Corp. for the courtesies extended to the Delaware Valley Section.

THOMAS P. CZEPIEL, *Secretary*

Empire State

The annual meeting of the Empire State Section was held at Whiteface Inn, Whiteface, N. Y., June 9–11, 1960. The meeting was highlighted by programs on the effect of the recent amendment to the Food, Drug and Cosmetic Act on packaging materials and on web drying.*

* The Papers presented at the Food Additives panel appear elsewhere in this issue of *Tappi*.

Once again a fine attendance record was set, with nearly 400 members and their wives enjoying the three-day meeting.

Honored at the meeting was Frederic W. O'Neil, retiring chairman of the section, who received a Certificate of Appreciation from National TAPPI, and Mr. and Mrs. J. G. Bullard

FDA Panel: Seated—J. K. Kirk, Food & Drug Admin., Dept. of Health, Education and Welfare; C. R. Calkins, Riegel Paper Corp.; R. C. Crain, Rhinelander Paper Co.; Ralph T. Russell, Syracuse University, and E. I. Stearns, American Cyanamid Co. Standing—J. C. Rice, Lowe Paper Co., and F. W. O'Neill, College of Forestry, University of New York

Drying Panel (left to right): W. L. Thomson, E. W. Wiegand Co.; Paul Goldner, J. O. Ross Engineering Co.; Allen F. Holmes, Sealright Oswego Falls Corp.; J. A. Villalobos, J. O. Ross Engineering Co.; Anthony Tortora, Black Clawson Co.

Junior Award Papers: Earl Johnson, Stevens and Thomson Paper Co.; Patrick Doyle, Finch Pruyn and Co.; W. H. Woodard, International Paper Co.

Awarding Honorary Membership to J. G. Bullard (left to right): J. Wayne Morrow, Newton Falls Paper Co., and Mr. and Mrs. J. G. Bullard, Corn Products Refining Co.

Presentation of Certificate of Appreciation to F. W. O'Neil, College of Forestry, University of New York, and P. E. Nethercut, TAPPI

of Corn Products Refining Co., who were made honorary life members of the section for their long and active participation in its affairs.

High Velocity Installations

P. Goldner and J. A. Villalobos

WITHIN the last few years the term "high velocity drying," has hit the paper industry with quite an impact and has caused everybody concerned with papermaking to take notice and, of course, start asking questions as to the effectiveness of high velocity drying in regard to their particular drying problems. The answers to these questions in part were determined from results obtained in laboratory tests which, in essence, are basically theoretical. To answer these questions thoroughly, the results of tests of actual installations should be provided. To be frank, this information is lacking and obtaining it sometimes is somewhat of a problem. To make tests on an operating machine, permission is not always readily granted. This is understandable, as any interference with production is usually not tolerated.

Since the basic theory has been presented in previous papers, we felt that test data obtained from actual installations would prove both informative and useful to the industry.

To bring the high velocity drying picture into focus, let us review some of the highlights which have been discussed in previous papers and articles.

The term "high velocity drying" is relative, and has been tried and used with varying amounts of success in the drying of every conceivable type of material. In the drying of paper, whether coated or uncoated, the velocity and temperature of the air has to be tempered to the product and designed to fit the application. This paper will only cover high velocity installations relative to the drying of paper on the machine.

In this instance, the basic concept is to utilize heated air from temperatures ranging up to 600°F. and possibly higher, and at a velocity around 15,000 f.p.m. to increase the productivity of the machine and/or using the high velocity drier as a tool for maintaining uniform moisture content across the width of the sheet. It should be understood that if both of these features are desirable, they can be accomplished through sectionalized units which can vary the velocity by volume control, sectionally across the sheet width.

Looking back to 1945, the first infinite impingement air system, the forerunner of high velocity drying in the paper industry, was designed and installed on a Yankee machine. But it was not until widely publicized magazine articles on high velocity drying that the paper industry awakened to the facts of its ever broadening possibilities for both on and off the machine drying applications.

Through necessity, the need for high velocity drying has become an important factor in paper mill expansion programs. Ordinarily, increased production demands were met by installing complete machines with ever increasing drier lengths or revamping present machines by adding additional driers. Either way proves to be highly expensive and sometimes impractical, because of space limitations in the machine room or of a new mill site.

Additional drying capacity is gained with high velocity driers at a lower cost and without loss of valuable operating floor space. Confirmation of its potential has recently been indicated by several machine builders, who undoubtedly realized that high velocity driers posed a serious threat to their own industry and are now offering air drying units in conjunction with their conventional machines.

Since time is the limiting factor, we will assume that previous papers published covering the high velocity drying theory have been read. Therefore, we will now present the results of several actual installations to show what type of units were used, and what was accomplished. Installations covering three different types of papers have been chosen because of the availability of the test data.

The first installation that we would like to discuss is the application of high velocity drying on tissue paper weights in the range of 10 to 30 lb. per 3300 sq. ft. In this case, the high velocity unit took the place of a Yankee air system which uses relatively low velocities at substantial distances from the goods. The machine on which this high velocity unit was installed consists of a polished 60-in. diam. creeping drier, followed by an after-drier section made up of eighteen 36-in. diam. steam driers. The high velocity unit was located around the crepeing drier with approximately 180° wrap. The unit was designed following our standard features, that is, nozzles $^1/_2$ in. away from the goods in approximately 3-in. centers, with return ports in between nozzles and velocities in the range of 15,000 f.p.m. The operating temperature of the unit is about 325°F. Without the high velocity unit, machine speed was 700 f.p.m. By putting the high velocity unit in operation, machine speed increases of up to 980 f.p.m. were attained. This speed change represents about 40% production increase. We can see from these results that the drying of tissue papers with high velocity air could be a very effective operation. However, we are still faced with the common problem of lint in the machine room that contaminates the recirculating air. This problem can be controlled by the following methods:

1. By using 100% fresh air (no recirculation), it is possible to eliminate a great deal of the problem. However, if the fresh air is taken from the machine room and the housekeeping conditions in the mill are not very good, the problem would

P. GOLDNER, Sales Engineer, and J. A. VILLALOBOS, Research Engineer, J. O. Ross Engineering Div., Midland-Ross Corp., New York, N. Y.

persist. Also, this method is not very practical economically, since all the heated air will have to be exhausted.

2. By using a good filter system for all the recirculating air and maintaining a rigid filter cleaning procedure it is possible to control the problem effectively. Certainly, if the production increase made possible with the high velocity unit is substantial, cleaning out of the filters should not be a serious objection.

3. By designing the unit with oversized nozzle openings this problem could also be controlled. However, to maintain the same drying capacity it would necessitate larger equipment and higher operating costs.

The most practical of these solutions to the lint problem would depend upon the specific installation.

As a summary for this first application, we can say that the drying of tissue papers with high velocity air has proved successful, but considerable thought should be given to the question of keeping the air clean.

The second application covers the drying of sizing and moisture leveling in an after-drier section. The paper machine on which this installation was made produces magazine and writing papers. At the time of our evaluation, the machine was making 40 lb. per 3300 sq. ft. white tablet. The high velocity unit is installed on the first bottom drier of an after-drier section consisting of seven 48-in. diam. cylinders. The paper leaves the size press with a moisture content of about 35% wet basis. The purpose of this installation was to level the sheet and add extra drying capacity so that the steam pressures in this section could be reduced. This reduction, in the drier surface temperatures, brings about less picking and better paper quality. This particular installation is operated with air at about 300°F. but the unit is used with lower temperatures on the lighter grades, since the added drying capacity is not required. The moisture leveling of the sheet is accomplished by means of our standard DL-type air drier. This design consists of a continuous shell which is partitioned, and then each section has its own supply and return air control so that the air velocities can be varied. As we know from previous discussions on high velocity drying, the change in air velocity brings about a very definite change in the drying rate. Therefore, by means of velocity control, it is possible to vary the amount of water taken out at different points across the paper web. The velocity change could be accomplished by remote control; that is, the valves feeding each one of the sections of the hood are operated by air cylinders which can be positioned from an instrument panel board. In the installation we are discussing, because of its location right after the size press, there is ample room for an operator to set the valves manually.

As a summary for this second application, we can say that the high velocity air can be used to control the selection of certain grades of paper on cylinder driers and, very definitely, for the first time in the paper industry, it is possible to produce, easily, a sheet of paper with a very flat moisture profile.

Finally, we would like to discuss the drying of heavy foodboard of a caliper range of 8 to 26 points. The paper machine on which these high velocity units were installed is made up of fifty-six 60-in. diam. driers divided into three drier sections. Four units were installed in the second drier section on driers nos. 16, 20, 24, and 28 which are alternate top driers. All the units were of the DL type. The main purpose of this high velocity installation was to increase the drying capacity of the machine. These units are direct gas-fired, designed for 600°F. maximum supply temperature and arranged so that two drier heads are supplied from one apparatus. From the study of the machine performance we found that the moisture in the sheet entered the second section at about 52 to 55% moisture and left at about 37 to 40% moisture wet basis. Extensive testing was performed on this machine and the results give a very good picture of the performance of several units in one drier section. In this particular installation we found that with the four high velocity units operating at design conditions, it was possible to achieve a production increase of 37%. On an average basis it comes out that each cap was doing the equivalent of somewhat more than five conventional steam driers. Specifically, this is not a value to use as a general rule of thumb, because of the moisture content in the board, the possibility of the diminishing performance when several high velocity units are installed in one drier section, and many other variables in the machine could change this value over a wide range. Actually, studies on paper drying in our laboratories and also reports in technical journals show that there is considerable difference in the way the same grade of paper dries under different conditions. It is for this reason that it is not advisable to make general statements regarding the number of steam driers a high velocity drier could replace without first making an intensive study of the machine.

We see then that high velocity drying can be used successfully over a wide range of paper grades. Even though the discussion today is geared primarily to paper drying on the machine. High velocity is also being used in many other areas of the paper industry.

You are all familiar with the application of high velocity drying to coated papers. Here again is a field in which there is still a great deal of work to be done in order to find how extensively high velocity drying can be utilized. At the present time studies are being conducted as to the effects of high velocity drying on such properties as printability, adhesion, rub strength, etc.

From these observations we might conclude that the true potential and effectiveness of high velocity drying has only been touched upon. To date, there are many high velocity installations for which test or performance data are not yet available. It is our hope that in the near future, with the necessary cooperation between the paper manufacturers and our technical departments, additional information will be forthcoming. Meetings such as these will certainly help to promote the understanding and cooperation necessary to insure improved future developments so that the entire industry will benefit and continue to grow.

Presented at the meeting of the Empire State Section of TAPPI, held in Whiteface, N. Y., June 9-11, 1960.

Measurement of Force of Stripping Sheet from Paper Machine Wire

W. R. Woodard

The speed on the open draw paper machine depends on the wet web strength of the sheet. The place where this is the deciding factor is at the open draw. It also depends on the force required to separate the sheet from the wire. It had been observed that at times the edges of the sheet were in a tight condition with no slackness, but at other times there was a definite looseness of the edge causing a "baggy edge." When the latter condition existed it definitely affected the running of the machine. It was decided that the reason for this varying condition should be investigated. The first step appeared to be to develop a test which would measure the force required to strip a wet sheet from a wire surface. A search of the literature uncovered an article by Howe, Lepine, and Gregory in the *Pulp and Paper Magazine of Canada* of April, 1959, describing such an apparatus. An instrument of the same basic design but with radical modifications was built. In our instrument we used a regular fourdrinier wire rather than TAPPI sheet machine wire. We pulled our sheet at a constant angle of 60° from the wire at a constant speed and measured the force by calibrating the extension of a light spring rather than strain gages as initially we couldn't find strain gages sensitive enough. The Canadian apparatus

W. R. Woodard, Research Division, International Paper Co., South Glens Falls, N. Y.

was equipped to vary the angle of release whereas as stated our angle was constant. It was our desire to eliminate as many variables as possible and relate our measurements to changes in stock furnish.

The ring which normally holds the forming wire is replaced by a brass ring about 2 in. larger in diameter than the sheet mold. This ring is mounted on four spring loaded legs. The supporting grid and backing screen are the ones normally used. When the sheet mold is closed the forming wire is supported on this grid and screen, but when the mold is opened the legs pick the wire up off the backing. The wire screen on which the sheet is formed is a piece of 80 by 60-mesh paper machine wire. A 90 mm. square form is placed in the center of the wire before the sheet is made. A vacuum pump is connected into the line between the sheet mold and the sump to insure a constant moisture content of the sheet.

The sheet is formed by the usual method, after which vacuum is applied to the sheet from below. The sheet mold is opened while the vacuum pump is running, thereby preventing water from being reabsorbed into the sheet from the backing grid.

After the sheet has been formed and partially dewatered by the vacuum the square form and the outer portion of the sheet are removed. The forming wire and supporting ring are then placed in position for the test. One edge of the sheet is loosened by hand and the clamp fastened to this edge.

The motor is started and the scale reading observed as the sheet is stripped. After the sheet has been stripped a second reading is taken with the sheet suspended from the scale. The first reading minus the second gives the force of stripping.

On the work done so far the moisture content of the sheet has been kept constant at 18 to 20% O.D. The moisture content of the sheet is controlled by the length of time that the vacuum is applied. This time varying according to several characteristics of the pulp. For paper machine stock of 170 to 270 freeness 5 to 10 sec. is needed for most groundwood. From 30 sec. to 3 min. is needed for kraft and sulfite depending on the amount of refining which has been done on the pulp.

The take-off angle has been kept constant at about 60° and the take-off velocity is also constant at about 61 i.p.m. All conditions were kept constant since we were interested in the behavior of different kinds of pulp under equal conditions.

The groundwood tested was sampled at the grinder pits and at the groundwood regulator. The bleached kraft tested was southern pine kraft. It was processed in the Valley laboratory beater to varying freenesses. The bleached sulfite was sampled with unrefined and then with one pass through a jordan at two different settings.

For groundwood in the lower freeness range the force of stripping increased quite rapidly as the freeness decreased. The force went from 17.5 g. per 90 mm. at 70 freeness to 28.2 g. at 35 freeness. At higher freeness levels the rate of change was much slower. At 175 freeness the force was 10.5 g. per 90 mm. as freeness dropped to 70 the force only increased by 7 g.

For bleached kraft the rate of change of force of stripping from 185 to 500 freeness is nearly constant. Above 500 freeness it levels off quickly.

The bleached sulfite was tested at 635, 610, and 561 freeness. Over this small freeness change the sulfite curve parallels the kraft and is nearly identical.

From the data it is very difficult to draw any other conclusion than the fact that we have a definite method to test for the force required to strip a wet sheet from a paper machine wire.

We have been unable to date to get enough varying conditions on paper machine stock to correlate there data to machine performance. It is hoped that in the future this will be obtained.

It would appear that the freeness of the groundwood pulp used is the controlling factor effecting force required to strip the sheet from the wire and that if the percentage of kraft and sulfite furnish is kept constant with a normal amount of refining that they would have very little effect.

I believe that this study has merit and can give us a better understanding of machine operation and is definitely worthy of further investigation.

Presented at the meeting of the Empire State Section of TAPPI, held in Whiteface, N. Y., June 9–11, 1960.

Practical Color Matching Using a Trimbey Metering System

Patrick J. Doyle

MATCHING color is an art in itself. To try and match color on a paper machine running a thousand feet a minute is an art too, but at a much faster pace. In the next few minutes, I'll try to paint a picture of what a color man does before and during a color run to insure a close match of paper being run. At Finch, Pruyn, the man directly responsible for a shade match during a color run is the pulp preparation foreman.

Preparation prior to starting a color run is as important as the actual run itself. Sound planning is the key to any successful operation, and it holds true for any color run. First consideration is posting of color formulas well in advance so that chemical makeup men can check inventories for the necessary dyestuff. The selection of tanks to be used is of utmost importance. In our color storage area we have stainless steel tanks ranging in capacity from 100 to 225 gal. Dyes to be used during the coming color run are separated according to expected volume to be used. Dyes with large volume usage are put into our 225-gal. tanks. Dyes with smaller volume usage are put into smaller storage tanks. You are probably wondering why so much emphasis is placed on selection of tanks. The chemical makeup men in our plant make up dyestuff along with the rest of their duties, which include making starch solutions, chemical preparation, etc. As you can see, they have to take up color in large quantities; hence, the care taken in selection of color tanks. Color formula data sheets have all the necessary information on them for chemical makeup men. The weighing of each dye to be used is carefully watched to insure correct dye strength addition to pulp. Color formulas give exact pounds and ounces of dye to be used with a given amount of water. In our system at Finch, Pruyn, we make up at 45 gal. per batch rate. We are equipped to make batches of 225 gal. at one time. Three 225-gal. stainless steel color storage tanks have cold water, steam, and agitation for color mixing, if needed. As a rule, these are not used as mixing tanks but for storage purpose only. The majority of our dyes are made up in a 50-gal. stainless steel mix tank equipped with a high-speed agitator. This mix tank is piped to each of eight color storage tanks off a common heater. Sewer lines extend from each color storage tank and mix tank for cleaning purposes.

Next step in our prerun preparation is selection of color meters to be used. Color meters are measuring devices common to the Trimbey metering systems which are in use at Finch, Pruyn and Co. Color meters are selected according to amount of volume they can pass. Records of previous runs are very helpful to us when making preparations for a new run. Checking back over these records gives us a starting point for gate settings on color meters and also the correct size of meters to use for individual dyes. The amount of dye used will change from run to run even though no drastic change has been made in furnish, etc. I've seen some runs vary as much as 25%; but average changes, from one run to the next, will vary only about 5 to 10% in the amount of dye used.

PATRICK J. DOYLE, Finch, Pruyn & Co., Glens Falls, N. Y.

Color meters are calibrated twice a month to insure against leakage and wear. Each color meter is piped into a sewer line for quick and sometimes sudden changes. Color flow from meters is piped to Trimbey discharge troughs containing pulp furnish or direct to machine chests.

All preparations are now completed for the expected color run. Color is in storage tanks and, where possible, admitted to the color meters. Lines from tanks to meters are checked for possible plugs early enough to remove obstructions, if found.

Each color run is started with an empty machine stock storage chest. Fresh pulp and color are started at continuous feed to the chest. Of necessity, fresh water is used for startup on each color run. The wire pit is doctored with a predetermined amount of color to overcome fresh water startup.

The first paper off the machine is checked for ash and color match. If previous color gate feeds are correct, then the match should be close. Small adjustments will bring color to a close match.

If (and I use this quite loosely) color is light, and most generally it is on startup, it is wise to wait a few minutes before making any color addition changes. Color changes at Finch, Pruyn can be made within minutes from each other with the use of the automatic Trimbey metering system. Color matching is at a much faster pace with an automatic feed system.

Correct alum addition is essential. We try to maintain a 4.3 to 4.4 pH when on colors.

The raising of size feed sometimes helps retain color in sheets, if needed.

Color should build up to a maximum point before one-half reel is turned up. Once color is acceptable, then the pulp preparation foreman informs the machine room foreman that color is now a good match.

The major source of trouble encountered on a color run is a high or a low ash content of the sheet. Uniform ash tests during a color run are of prime importance. Ash changes of 2 to 3% are quite noticeable during a color run. One policy at our mill is that no additional color is added or taken out when ash tests are out of specification. Finish of paper will sometimes hinder color matching. High finish paper uses a lot more color than a sheet with low finish. The blackening effect from a full stack tends to cover up color, hence the need for more.

It is economically sound and, of course, a source of great personal satisfaction to match color with as little lost paper as possible. As I said before, careful preparation in advance tends to make a success of any attempted project, and color is no exception. Close team work, good communication, and careful observation are essential to get the job done right.

I'd like to mention now that there are occasional frustrations encountered by a color man, and this is usually connected with a new color. Also, getting the right shade can be particularly bothersome when two, or sometimes three, dyestuffs have to be fed through the meters simultaneously.

When paper is found to be *not acceptable* because of off-color, that is the most frustrating part of the job. However, there is usually a reason and it is now our problem to find out "why" and correct the situation as quickly as possible.

Presented at the meeting of the Empire State Section of TAPPI, held in Whiteface, N. Y., June 9–11, 1960.

The Training of Present and Future Personnel

Earl L. Marshall

One of the main concerns of business today is the rising cost of material. If a company can control their costs, they are in a better position to price their product. A company whose cost varies everytime an order is made, cannot tell a true cost point. No matter how much control is established, an order will not run exactly the same each time.

We find this true in our mill because we use a reclaiming process. As every bale of waste that we use may vary in contrast to each other, this creates a difficult control problem. With a situation like this, I found the men in the mill could not react to the change because they did not understand the material they were working with.

I circulated around the mill and spoke to these men who were adding the material to the stock. I asked them two questions:

1. Why are you adding this material to the stock?
2. What does it do?

Now let's take these two questions one at a time and discuss them a little further. Why are you adding this material to the stock? The answer I received in the majority of cases was the running orders called for it. I found the men did not know the real reason why they were added.

What does it do? I found that only one out of six men had any idea why a material was added or what it did or what it was used for.

What was done to try to remedy this problem was to set up a training program. This was almost an impossibility in our mill because the men did not have time from their jobs to attend a group meeting. So by trying to reach one or two men at a time, was the only way this could be accomplished. This plan has worked out well because all the key men have been reached in our mill.

An example of the results of this program is the reduction of our sizing costs. We were sizing a double news vat-lined sheet to a saturation point of 15 sec in boiling water. The cost of this order was running over a period of 11 months at $5.50 to $12.35 per ton. During the last 4 months, our sizing costs on this same order has been $4.75 to $6.00 per ton. This variation is due to the chemicals, which we have found in the waste paper that we use. This cost reduction is due to better handling of materials through better understanding. A cost reduction in our dyestuffs has been achieved through the use of this programing also.

This brings me to the main topic of my paper: The Training of Present and Future Personnel.

The men we train today will be in the position to further the pulp and paper industry in the next few years. As you all know, the paper industry is one of the top ten industries today in the United States. With the increase in our technical know-how, and with more technical trained men, the pulp and paper industry could be one of the top industries stepping aside only for the steel and auto industries. To do this we need more trained men.

With more of our college graduates going into engineering and electronic fields, the pulp and paper industry is falling behind in the acquirement of technically trained men. The majority of our trained men comes into the industry from one of the universities which has a course in pulp and paper manufacturing. The graduates of other colleges today do not see the future that lies ahead in the pulp and paper industries. With the loss of these men, it means we are going to have to look other places for our technically trained men. There are many places and ways in which to find these much needed men.

The idea I have in mind would not solve the problem completely, but it may be a step in the right direction. Let's stop a minute to when each of you entered the pulp and paper industry. What were your reactions to the industry when you entered it? I know I can safely say that in the majority of the cases, you saw the great challenge that lie ahead of you. Without an increase of our technical trained men, how are we going to meet this everlasting challenge which is always there? A new man entering the pulp and paper industry 50 years from today will still see newer and better ways to do the same old jobs.

Earl L. Marshall, Smeallie and Voorhees, Inc., Amsterdam, N. Y.

Let's get back to our present problem of finding a supply of trained men. This problem can be solved in many ways. The first and easiest way is to work with the men that are already in the industry. If a mill would establish a technical training program for the men they already employ in the actual production of their product, they could release more of the college trained men who now hold less important jobs. These men would be free for more important work in research. This training program could be set up in many ways. One of the ideas I have is a training program set up as an apprentice course. This course would be in the technical department of the business rather than the production department. This type of course would also bring new men into the industry. A number of industries are using this apprenticeship program to train young men to assume supervisory capacities. We have a large number of young men today graduating from high school and coming out of the services who were in the upper portion of their class, but due to circumstances, they could not further their education. In these men may lie the answer to our problem of today.

Another way to do this is if a mill would sponsor a young man with the ability through college. This idea is not in the form of a scholarship. The young man would be required to work in the mill during his summer vacations for practical experiences and to also help pay the cost of his education. Upon graduation you would have a man with the practical experience and with the technical ability to do a good job for the industry.

I could go on further into this training program as I have given it considerable thought. With the industry's help, there could be in the next few years a 100% increase in the number of technically trained men graduating from the pulp and paper schools. If each mill did sponser a young man through college, or another training course, there would be over 100 technically trained men per year in New York State alone. As you can see, there are a number of ways to meet our need for trained personnel and if the industry is to grow, we must grow with it.

We are planning in the near future to establish a full-scale personnel training program. This program will be held for the men that work in the actual production of our products. It is known that every man will strive to do a better job if he thoroughly knows his job. Through this training program, we hope to bring about a cost reduction in the use of all material used, as I have shown what was done in our mill with a small scale training program in the first part of this paper. We at Smeallie and Voorhees feel this is a worthwhile project. We hope in the future to be able to say that all of our men are thoroughly trained in their prescribed jobs. Our first step in this program, which we are planning is a seminar on the proper handling of alum and rosin.

Presented at a meeting of the Eastern District of the Empire State Section of TAPPI, held in Glens Falls, N. Y.

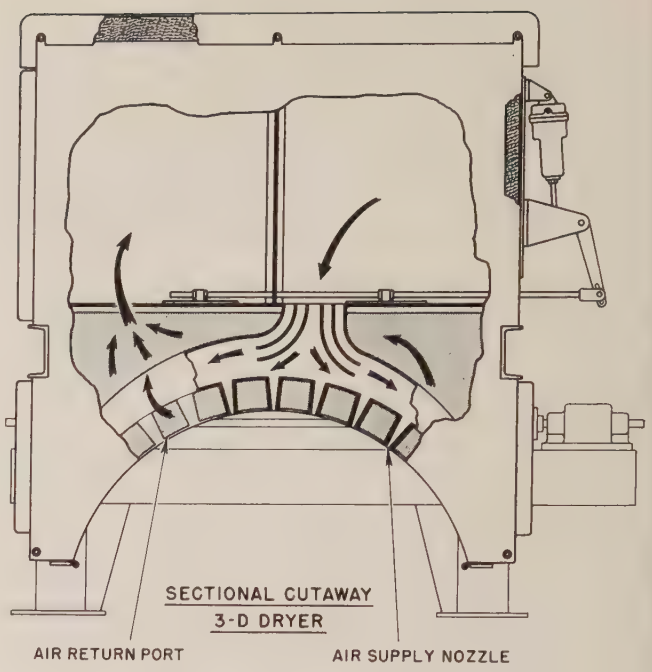


Fig. 1. Section cut-away of 3-D high velocity drier showing profiling dampers, air supply and air return ports

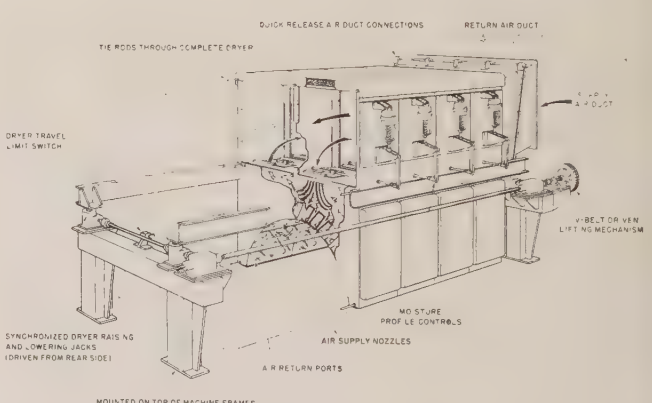

QUICK RELEASE A R DUCT CONNECTIONS
RETURN AIR DUCT
TIE RODS THROUGH COMPLETE DRYER
DRYER TRAVEL LIMIT SWITCH
V-BELT OR VEN LIFTING MECHANISM
MOISTURE PROFILE CONTROLS
AIR SUPPLY NOZZLES
SYNCHRONIZED DRYER RAISING AND LOWERING JACKS (DRIVEN FROM REAR SIDE)
A R RETURN PORTS
MOUNTED ON TOP OF MACHINE FRAMES

Fig. 2. Schematic drawing of Black-Clawson 3-D high velocity drier assembly

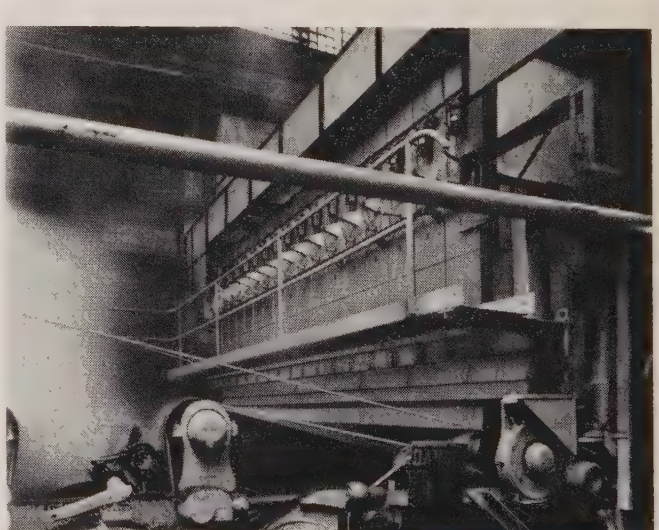


Fig. 3. 3-D drier installed on wide, high-speed kraft machine. Adjustable moisture profiling damper arrangement is shown—across front surface of unit

Accelerated Drying for Paper Machines

A. V. Tortora

Due to many requests made by the pulp and paper industry of the Air Systems Division of The Black-Clawson Co., at Hamilton, Ohio, I am here today to give you as much information as possible on the construction, the effect on drying, and how this drying is accomplished by the 3-D drier. I would also like to cover some of the applications on the high velocity air driers and where we think they should be installed on the machine.

In general, the 3-D high velocity air drier covers a little less than one-half the diameter of the cylinder on the paper machine—say approximately 150° located on the top or on the bottom of the drying cylinder. The degree of wrap

A. V. Tortora, Sales Engineer, The Black-Clawson Co., Air Systems Div., Hamilton, Ohio.

depends entirely on the local conditions and the degree of wrap varies as much as 20 to 30°.

The 3-D drier comprises a multiple of standard 15-in. sections which are made to fit 36, 48, 60 and 72-in. diam. driers, or larger. The only change in the standard width is either the middle section or the two end sections. These can vary as much as from 15 in. to approximately 25 in. Each section is of all-welded construction. It is readily apparent that driers built with standard 15-in. sections make it easier to handle warping than to weld up a drier all in one piece. Each section of the drier is separated with a high temperature gasket material and the sections are bolted together with through bolts with spring-loaded nuts. The drier is then supported on structural steel attached to each of the sections. The structural steel is, in turn, supported from the machine frame.

A profile control is built into each section of the 3-D drier. This equipment consists of supply and exhaust damper arrangement controlled from a console or instrument panel located on the machine room floor or attached to the hood. Through a series of bell cranks and stainless steel control rods are cylinders that actuate the movement of the profile dampers from air switches located on the console. This action will supply the correct volume of air to each 15-in. section to the drier and, in turn, will supply the right volume of air to the sheet being dryed. The profile damper arrangement provides instantaneous control over wet streaks in the sheet. It is not necessary to have profile control on each 3-D drier on the paper machine, but it is suggested that profile control be installed say at the last drier at the wet end and the first drier after the size press or coater. The construction of the 3-D drier allows installation of profile control at a later date if the characteristics of the machine show that additional profiling is needed. This latter control can be made a semipermanent adjustment.

Synchronized screw-type lifting jacks are located on each corner of each drier. They normally lift the driers anywhere from 9 to 12 in. The screw jacks are operated from a motor, usually a high torque type with a magnetic break. Limit switches control the up and down position. The weight of the drier is not left on the screw jacks, but rests on supporting legs in the down position.

The supporting steel across the drier is prestressed on larger width driers so that there is uniform clearance between the center of the 3-D drier and the steam drier face.

Black-Clawson has 3-D driers spanning 20 ft. across the face of the steam dryer without any difficulty from deflection.

The advantages of the 3-D drier for drying are important to paper mills faced with limited space for paper machine drier expansion; for mills contemplating the addition of size presses and coaters to their machines, and mills that have difficulty with unevenness in drying the sheet because of faulty suction presses or caused by the characteristics of the machine drying pattern. A few of the advantages of the high velocity air drier are that picking of the sheet is reduced by running the first driers with reduced steam pressure. The evenness of the moisture in the sheet on the dry end is a direct result of the profile control and does not require rewetting of a sheet or the use of a sweat roll. The resulting uniformity of moisture in the sheet will also provide for better calendering. Also, the tear and burst characteristics should increase while the curl decreases.

Accelerated drying is accomplished by 3-D driers primarily because the high velocity air drier supplies a large amount of air per square foot and the air delivered to the sheet is traveling from 16,000 to 18,000 f.p.m. at right angles to the sheet. The exhaust air from the 3-D driers is controlled and is taken through each 15-in. section. Exhaust is not drawn across the sheet to the outside of the hood. The temperature of the supply air to the sheet being dryed is preferred to be approximately 600° with the system being gas fired. Six-hundred degree air tends to give twice the drying efficiency of steam heated system supplying 280 to 300° air. Each 3-D drier delivering 600° air is equivalent to approximately three steam-heated driers on the machine, depending on its location on the machine and the type of paper being dried, plus other variables.

The system on the 3-D drier is semiclosed. It has a supply fan, an exhaust fan, and a combustion fan when using gas for heating. The supply air, after doing its work, is returned to the casing. The air is reheated; additional fresh air from the room is added with the combustion air. This air is then recirculated through the system. The exhaust air is bled off the system before reheating. The amount of exhaust air expelled to the atmosphere depends again upon the type of system; how the air is being heated; the type of paper being dried, etc. A gas fired system is designed to recirculate more air than the steam heated system, but any system has to be adjusted to meet the local conditions and characteristics of the paper machine.

The expense of supplying any high velocity air drying is a cost that has to be added to a normal cost for drying the paper.

The location and application of the 3-D driers vary on the paper machine almost as much as the type of paper it is drying. In general, it has been found through testing and on various installations, that the 3-D high velocity air drier does its best drying job at the wet end of the machine and just after a size press or coater. Any intermediate location for a high velocity air drier on a machine will vary in drying rate and each system must be treated individually. It has also been found that there are no two high velocity air drying systems the same.

It must be remembered that a 3-D drier is not a cure-all for all the drying difficulties you may have on a machine, but it will give you a good boost for extra drying needed. The paper mills must cooperate with such an installation and they must participate in sharing the responsibilities. They must learn to start, operate, and maintain this equipment and learn to change the temperature and damper settings to provide for the most efficient drying of the different grades and specialities in paper being produced on a given machine.

The 3-D drier should be located where it will do the most good, or where the biggest problems in drying lie. They can be located on the top and bottom of the drying section, but the latter location offers many space limitations which are normally avoided. Some of the more common locations for 3-D driers is, naturally, anywhere along the machine except between the calender stacks or before the size press.

Presented at the meeting of the Empire State Section of TAPPI, held in Whiteface, N. Y., June 9–11, 1960.

Golden Gate

The May 10 meeting was held at the Hotel Claremont in Berkeley, Calif., with 71 men present.

We were honored by having James R. Lientz, president of National TAPPI, present our chairman, John Hartsock, with a charter as the Golden Gate Section of TAPPI, and also the gavel and banner for our Section's use.

As the Robert True Memorial Lecture, we had a very fine paper presented by J. L. McCarthy of the University of Washington.

At the recommendation of the Nominating Committee, the following officers were elected for the coming year:

Chairman: H. W. Theller, Crown Zellerbach Corp.
Vice-chairman: H. L. Rammer, Fibreboard Paper Products Corp.
Secretary-treasurer: W. R. Brandt, General Aniline & Film Corp.
Recording secretary: L. G. Maclise, Dow Chemical Co.
Executive committee: D. F. Church, Crown Zellerbach Corp.; E. R. Padavic, Container Corp.

Gulf Coast

The Gulf Coast Section held its final meeting of the 1959–60 season at the Jung Hotel, New Orleans, La., on May 13 and 14, 1960. The meeting started off Friday evening, May 13, at 6:00 p.m. with a delightful social hour, followed at 7:00 by a steak dinner. After the dinner, Chairman Elsevier called the meeting to order for a short business session. The main order of business was the election of officers for the next year. The nominating committee, consisting of R. R. Fuller, chairman, V. F. Waters, and L. A. Thompson, recommended the following slate of officers:

William Elsevier, Chairman
A. L. Hargraves, Vice-Chairman
H. Murphy Owen, Secretary
M. T. Still, Treasurer
W. P. Shannon, Executive Committee
J. E. Doyle, Executive Committee
I. S. Walker, Executive Committee
R. R. Fuller, Executive Committee

This slate of officers was accepted by a unanimous vote.

Mr. Elsevier then introduced J. E. Sapp, program chairman for the evening, who introduced the speaker. Harry H. Saunders, vice-president of St. Joe Paper Co., spoke on "What Executive Management Desires and Expects from Technical Personnel and Technical Associations." This concluded the evening meeting.

On Saturday morning William Elsevier served as moderator for the technical program. Speakers were:

1. L. W. Perdue, International Paper Co., Pine Bluff, Ark. "Operation of Pine Bluff Chemical Furnish System."
2. W. E. DeMiller, Jr., Scott Paper Co., Mobile, Ala., "Coefficient of Friction Determinations on Paper."
3. T. P. Crane, Jr., St. Regis Paper Co., Pensacola Fla., "Comparison of Valley and Dilts Laboratory Beaters."
4. Baynard Malone, St. Joe Paper Co., Port St. Joe, Fla., "Modified Chlorine Number Tests." The author, Mr. Malone, was unable to be present, and his paper was read by A. L. Hargraves.

M. T. Still, *Treasurer*

Operation of Pine Bluff Chemical Furnish System

L. W. Perdue

Today, I want to talk to you on the subject of chemical furnish at the Pine Bluff mill and will want to emphasize the importance of instrumentation for control of slurry densities. I would like to refer to an article from the *Southern Pulp and Paper Manufacturer* dated Jan. 10, 1959, covering the write-up of the Pine Bluff mill. This should give you a brief introduction to our chemical furnish system which is a completely revolutionary furnish system that will, no doubt, serve as a model for future installations.

After we have briefly covered the overall description of this furnish system, it would be interesting to point out some of the things that make such a system possible and practical.

The article reads as such:

"Complete Chemical Furnish—from railroad car raw material to finished paper—for two machines from one unitized system. This, coupled with elimination of wastage, continuous control of quality of furnish preparations, and savings realized from bulk handling methods, tells part of the story of the Pine Bluff mill's furnish installation.

"This installation, consisting of a separate building and tank farm, is located between two railroad tracks. One track is used for bringing in hopper and tank cars of bulk material (clay, starch, rosin, and wax sizes). The other track parallels an unloading dock for receiving bag and drum material (a dozen or so items). Alum is received by underground pipeline from a nearby chemical plant.

"The bulk materials are unloaded into the proper storages and prepared on a continuous basis by equipment that is instrumentized to require a minimum of attention by the operator. The material that is received in bags and drums is prepared batchwise as needed by the operator's helper and is supplied to the paper mill continuously as necessary. A continuous color preparation system is included for each of two paper machines. A panel board inside the building near the doorway to the tank farm contains instruments that record levels of all tanks and storages. It also contains controllers that regulate temperatures, flows, and concentrations where necessary on the bulk preparation items.

"All of the materials are pumped by pipeline from the furnish building to the point of consumption. One dilute alum line goes to the groundwood pulp mill, and the starch slurry lines go to the size press and calender system in the paper mill. All other lines go to various points in or near the beater room for direct addition to the stock system. The flow of all items going to the beater room is indicated and controlled from the beater engineer's panel board. The beater engineer is able to start and stop chemical furnish pumps, regulate the flow of the individual furnish items, and ratio these flows to the stock flow without leaving his panel board. A paging type intercommunication system furnishes communications between the beater room, the starch system, the machine backtender, and the furnish building.

"The starch system receives its starch slurry from the furnish building and prepares the starch for use on both the size press and calenders of the food board machine. The slurry is measured into separate cookers for size press and calender preparation. After cooking, the calender starch is diluted to the desired concentration and applied to the machine. The size press starch, however, is pumped continuously from its cooker to a dilution tank where the concentration is adjusted by a density control instrument. The excess return starch from the size press comes back into this same dilution tank so that the solution going to the size press is continuously controlled to the proper concentration.

"The key to the efficient operation of a furnish system of this magnitude is instrumentation to a degree rarely approached in previous installations. An example of this instrumentation, as applied to the starch handling system, follows:

"Bulk starch is received in railroad hopper cars and unloaded by mechanical conveyors into glass-lined steel silos. Capacitance-type instruments indicate the level in these silos. Rotating drag-out conveyors remove the starch from the bottom of these silos and supply it to vertical screw conveyors, which put the starch into stainless steel slurry tanks fitted with agitators. When a batch of starch slurry is removed from a slurry tank, a level recorder-controller starts mill supply water into the slurry tank. The water runs until the level returns to the set-point; a density recorder-controller senses this dilution and starts the dry starch conveying system which runs until the density of the slurry is built up to the set-point. Thus a continuous supply of starch slurry of the proper concentration is kept available for the machine starch system, but requires no manual work from the operator. He only checks the system as necessary.

"This type of imaginative, practical approach to instrumentation is applied repeatedly throughout the chemical furnish installation and results in an efficient installation that is unique." (End of Article.)

How is all of this possible? It was carefully planned that way. The furnish system as we have it at Pine Bluff is possible, simply by instruments and engineer planning that allows us to measure and record the density of slurries. A differential transmitter and recorder was engineered into the systems to control densities of slurries. This made possible most of our bulk handling of dry solid materials.

All of you are familiar with the conventional bubble pipe level recorder. This may be a bubble pipe inside the tank or welded into the side of the tank. This is used to record changes in levels in a tank. For illustration, suppose that the liquid in the tank were water at standard conditions.

In recording the change in level you, by definition, must be measuring changes in volume or changes in weight, as the level in the tank rises and falls.

Adding another substance or mass to the tank of water would change the weight even at the same level. At this point, we should attempt to define slurry density, since it is of primary interest and will be referred to many times.

Slurry densities are actual values in pounds per gallon of solids in solution or suspension, but our methods for measuring and controlling give us these values as relative values, since we are dealing with specific gravity and Baumé, and use water as a standard of weight or volume. When we speak of specific gravity or Baumé of a substance or mixture, the comparison is always to an equal weight or volume of water at standard conditions.

To briefly state conditions that are necessary for controlling slurry densities, there should be two bubble pipes in a tank and at the same level. Both of the bubble pipes will necessarily record the same level and pressure or weight. If both bubble pipes are shielded in larger tubes extending to different depths in the tank, there still would be no difference in pressure on the bubble pipes. But if a constant amount or flow of water were introduced into the upper end of each of the shielding tubes, there would be a difference in head or height of water standing in each of the tubes, because of their difference in depth of submersion. The difference in height is measurable, and there will be a difference in the pressure on the bubble pipes since the head in each tube has changed. The difference in the head of each tube is directly proportional to the difference in depth or submergence of the water tubes without respect to the level of water in the tank. Then any change in density of the water in the tank due to making a slurry or adding a solid substance will increase or decrease the differential head of water in each of the water tubes and subsequently increase or decrease the differential pressure on the bubble pipes. Through a differential pressure transmitter, we can then register any change in the density of the solution or slurry in the tank.

By proper control of pneumatic control valves, we can proportion the correct quantity of materials (water and solids) to control the density of the mixture or slurry, using the change in pressure signal from the differential transmitter.

The temperature of the slurry is one factor that affects density control. However, once the system is set to get the desired density, very little change in temperature occurs, and temperature is of no real consequence. We are able to dilute cooked starches at 165°F. very accurately to any Baumé desired and control to a constant density. Of course, we make sufficient hydrometer checks to set the controls which, once set, will control properly for that setting and temperature.

Through operating experience, we have made minor improvements in the system which would be of interest to you at this point. Any amount of agitation in the tank will cause fluctuations in the differential head of the water tubes and prevent good control. On tanks where we have slurries that require a great deal of agitation to keep the slurry solids in suspension and where we make sudden changes in the level in the tank by intermittent pulling of large batches, we have made provisions for better control.

A stilling pot outside of the tank was constructed in which to mount the bubble pipe control system. All of our slurry lines have returns so that we are always pumping slurry to the point of consumption and the excess returns into the same tank. We piped slurry from the discharge of the pump through the stilling pot, and it returns by gravity to the tank. This has helped us to gain almost perfect control of the density of slurries.

I'm sure by now you are wondering just how accurately we can control the density of slurries. In normal operations, we control the density of clay slurry to 3.0 lb. per gal. accurate to 0.03 lb. per gal. by dry solids test. We control the density of starch slurries to 2.0 lb. per gal. accurate to 0.03 lb. per gal. Any process that is operated to plus or minus 1% is evidently well controlled.

In concluding and summing up the advantages of being able to control the density of solutions or slurries which we have given so much attention, we have briefly lost sight of why it is so important. To really do justice, we must say that it does all of our heavy work. We should first consider how many men it would take to handle 12 to 15 tons of starch and 15 to 25 tons of clay in bags every day. Then, too, we must be just as accurate in measuring these materials from bulk storage as we would from 100-lb. bags, for usage in our furnish. We must give credit to this type of imaginative, practical approach to instrumentation that has proved far superior to our expectations. I know that once you have found an appropriate application for this type of control, that you will be well impressed with what it can do for your operation.

Presented at the meeting of the Gulf Coast Section of TAPPI, held in New Orleans, La., May 13, 1960.

Coefficient of Friction Determinations on Paper

Walter E. DeMiller

The coefficient of friction has been defined as "the ratio of the maximum force of friction between two bodies to the normal force pressing the surfaces together." The minimum force that will just cause one surface to slide upon another is the static friction. The force that will just keep the body in motion at a uniform rate is the kinetic friction. Generally, in the paper industry, we are primarily interested in the static friction. Experience has shown that once a bag *starts* to slide off a stack, it will continue to do so. If a cup starts to pull freely from a dispenser, then it will not pull another cup with it.

If we are to make paper with a uniform roughness or slickness, we must have an instrument to measure this quality.

There are several instruments for measuring the smoothness of paper. In general, they measure the rate of flow of air across the surface of the paper while it is clamped adjacent to some constant surface. This means that the smoothness by these methods is really a combination of levelness of surface, compressibility or softness, and lateral porosity. This is not to say that these instruments do not have a very important use. Our experience with the Sheffield smoothness tester has been that it correlates well with subjective judgments of surface. The Paper Shipping Sack Manufacturers Association recommends their modification of the Gurley smoothness test because they find a direct correlation with the appearance of the surface.

None of this type of instrument measures directly the slipperiness or antislide property of paper.

The simplest device to measure the coefficient of friction is the inclined plane. A tester can be made by joining one end of two sections of board about a foot long with a hinge. The hinge is set so that one board lies upon the other and so that the axis of the hinge is as near as possible in the plane of the upper surface of the top board. A large protractor is fastened to the back of the bottom board with its center point on a line through the axis of the hinge and the end of the 0° line at the edge of the top surface. The boards are adjusted so that the top surface is level.

Two samples are cut grain long from the paper to be tested. No certain size is necessary but they must be larger than the weight, which is described later. It is easier to cut both pieces the same size. We use the tabulating card size $3^1/_4$ by $7^3/_8$. The two samples are placed one upon the other with the sides to be tested adjacent to each other. The question of which sides to test is determined by the end use of the paper.

Walter E. DeMiller, Jr., Development Engineer, Scott Paper Co., Mobile, Ala.

If, for example, you are interested in the nonslip property of bag papers, you should test wire side to wire side. Generally, bags are made with the wire side out. If sheets of paper stacked on skids is your problem, you should test wire side to felt side. The same is true of cup stock or other papers which, in their end use, should slip one sheet at a time.

The pair of samples are laid on the top surface of the tester at the end away from the hinge and with the grain at right angle to the axis of the hinge. The upper sample should be offset $^1/_2$ in. toward the hinge so that the exposed end of the lower sample can then be held firmly in place with a spring clip. A weight is placed on top of the pair of samples. In theory, the amount of weight makes no difference; in practice, we obtain somewhat higher angles of slip as we increase the weight per unit area. This is not a real contradiction, but is due to the fact that paper is a compressible substance. With heavier weights, more area of the paper's surface comes in to contact and irregularities mesh together. Since the area of the base of the weight is the *effective* test area, it must be large enough to contain an area representative of the paper. We have tried several types of weights. The one most readily available is made by gluing a disk of rubber to the bottom of a 1-kg. weight. This has proved to be satisfactory in most cases. A lighter weight tended to give somewhat erratic results; possibly because an insufficient area was in contact each time. The limitation of this kilogram weight is its high center of gravity. On extra rough papers, which have an angle of slide in the neighborhood of 45°, the weight may fall down the plane before the top sample slides.

After the weight is placed on the samples, the unhinged end of the top board is slowly raised at a uniform rate. Any sudden movement or jarring will cause the sample to slide early; thus giving an erroneously low angle of slide. A motion that is too rapid will cause the observer to read too high an angle.

When the top sample and weight start to slide down the incline, the angle shown on the protractor at the edge of the top surface is recorded to the tenth of a degree. The coefficient of friction is equal to the tangent of the angle of slide. The proof of this is as follows:

Draw the inclined plane and the vectors of the forces on the sample at the top surface. Two forces are the normal force of the weight and the friction force-resisting sliding. From the vectors, form a triangle—one of whose angles is equal to θ (the angle of slide).

$$\text{Tan } \theta = \frac{\text{Opposite}}{\text{Adjacent}} = \frac{\text{Friction Force}}{\text{Normal}}$$

By definition,

$$\text{Coefficient of friction} = \frac{\text{Friction force}}{\text{Normal}}$$

Therefore,

Coefficient of friction = Tan of angle of slide

To eliminate any error due to lifting, some sort of mechanized device to raise the plane is desirable. We have used the return motion of the lower jaw of a T.M.I. tensile tester. A laboratory clamp is attached to the jaw and a strong cord is tied to the arm of the clamp and connected to a screw eye in the end of the top board. The cord absorbs any vibration. We built a motorized version of this instrument but so far are still having some difficulty obtaining complete correlation with other testers.

In our normal testing, ten slides are made, using the bottom sample from one slide for the top sample in the next slide. The use of repeated slides on the tester to evaluate nonskid properties after handling has been found useful. Repeated slides also help to measure the effectiveness of binders with various antiskid pigments. We have also used it to determine an approximate effect of polishing or rubbing on papers whose surface had additives to aid slipperiness. When running repeat slides, care must be taken to catch the weight after it starts its slide, so that the top sample is not creased at the end of the plane.

There are several commercial test instruments to measure friction. The other tester that we have used in our Mobile laboratory is the IBM card stock friction testing machine. This machine used a spring loaded gage to push a weight of 1000 g. in a horizontal plane. The spring gage measures the force needed to slide the weight and top card over the bottom card. Since the motion is in the horizontal plane, the normal force is the 100-g. weight; therefore, the coefficient of friction can be read directly from the spring gage. The samples are always tested wire side to felt side, since that is how the cards will be used. This instrument will indicate both static and kinetic friction; static by reading the maximum force at the time of the initial motion and kinetic by reading while the top card and weight are moving. Since the end use of IBM card stock involves motion in the sorting equipment, we are also interested in the kinetic friction on this paper. This instrument can be calibrated very easily. A cord is attached to the hook on the end of the spring gage shaft and is passed over a frictionless bearing (ball bearings on a glass rod shaft). Weights are tied to the end of the cord and the reading of the gage observed. An adjusting nut is turned until the pointer reads the correct value. One disadvantage of this machine is the pushing action. Lightweight samples are buckled rather than slid.

The Glass Container Manufacturer Institute has designed a friction tester. We made an attempt to correlate our inclined plane tester with this type tester and other testers. Only approximate agreement was obtained. In some cases definite disagreements were found. In all cases the GCMI tester gave lower values for the coefficient than did any of the other testers.

A new instrument, the NSTIC nonskid test unit has come on the market recently. It is an adaption of an impact tester. It consists of an inclined plane with a backstop at the bottom. A wheeled cart or dolly rolls a standard distance down this plane and then hits the backstop. The paper samples and weight block are placed on the dolly in a manner similar to the inclined plane tester. When the dolly hits the backstop, the top sample slides on the bottom sample. The distance of the slide is a measure of static plus kinetic skid resistance, but is not a direct measure of coefficient of friction.

All of these instruments have their undesirable features. The main drawback of the inclined plane tester is its failure to correlate completely with other testers. We have found it to be good for relative comparisons of paper. When measuring the static coefficient of friction, the inclined plane tester should be given first consideration.

Presented at the meeting of the Gulf Coast Section of TAPPI, held in New Orleans, La., May 13, 1960.

Comparison of Valley and Dilts Laboratory Beaters

T. P. Crane, Jr.

This paper is based on the results of a study made on Dilts and Valley beaters at St. Regis in Pensacola by the Research and Development Groups.

Variations in results of physical tests have been noted when identical pulp is processed in Dilts and Valley beaters. There has been, for some time, the question of whether these variations are caused by the beaters or their associated sheetmaking procedures.

With the Dilts beater, the standard practice at Pensacola is to utilize a Valley sheet mold system or Noble and Wood sheet machine system for sheetmaking. Sheets made with the Valley sheet mold are not dried under tension and shrinkage is not controlled. Sheets made with the Noble and Wood

Table I. Valley Beater

Cook no.	Tensile 20	30	40	50	60	70	80
	Tear 20	30	40	50	60	70	80
717	375	437	460	437	353	312	288
718	286	354	390	388	347	315	275
719	315	390	417	392	338	306	..
720	280	357	390	375	316	278	..
721	262	372	408	403	356	308	..
722	270	358	396	397	350	300	..
723	225	270	297	303	283	259	..
724	315	363	371	357	322	287	..
725	200	258	300	322	307	271	247
726	255	335	375	365	310	282	268
727	227	267	296	302	258	225	215
728	237	267	282	268	243	225	..
Average [Mean]	270	336	365	359	315	281	..
Standard deviation of single reading	50.0	56.4	58.1	50.5	38.7	29.6	..
Standard deviation of mean	14.4	16.3	16.8	14.6	11.2	8.5	..
Confidence limits on the mean	31.8	35.8	36.9	32.1	24.6	18.8	..

sheet machine are dried under tension and therefore shrinkage is controlled.

Standard practice for use of the Valley beater is to utilize the British sheet mold system. Sheets produced by this system are air dried under tension with controlled shrinkage.

Currently there is a study of outside chip storage of slash pine being conducted by St. Regis. Physical quality of pulp produced from these chips is evaluated by beating in a Dilts beater, forming handsheets on a Noble and Wood sheet machine, and testing for tear, tensile, and burst.

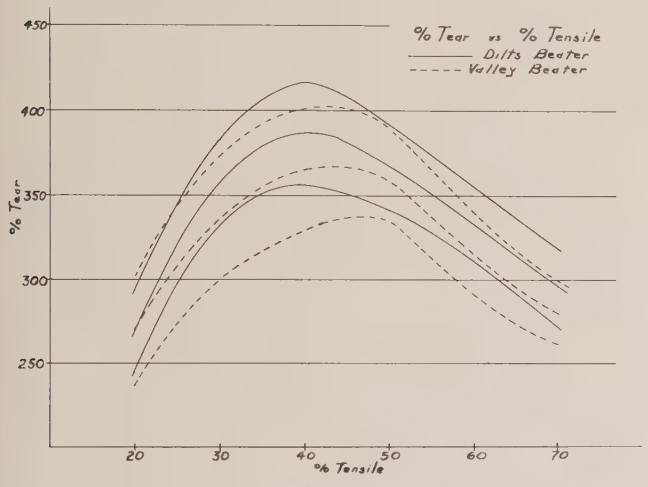


Fig. 1.

In order to demonstrate whether the difference in results of tests on pulp processed in Valley and Dilts beaters originate in the beaters themselves or in their associated sheetmaking procedures, it was decided to run supplementary tests on the outside chip storage project.

These supplementary tests consisted of beating samples of pulp in a Valley beater in correlation with the regular beating of portions of these same samples in the Dilts beater. The two beater charges, after refining, were processed with the same sheetmaking facilities, i.e., Noble and Wood system and tested, using identical test procedures for tear, tensile, burst and 5-g. S-R freeness determinations.

Twelve cooks were made under identical conditions in the pilot plant digester, with chips from the outside chip storage project for the correlation. Chips for these cooks were selected over a large cross-sectional area of the storage pile. We expected to find variations in pulp quality within the cooks due to differences in specific gravity, location within the pile, and bacteriological action on the chips during storage. However, these variations can be tolerated since they will be common to each beater and variations between beaters is the determination we are primarily interested in.

The Valley beater was charged with 360 g. of pulp at a consistency of 1.57%. The bed plate load was 5500 g. and 1700-ml. samples were taken at intervals of 20 min. for a total beating cycle of 80 min. The Dilts beater was charged with 11.45 lb. of pulp at a 3.25% consistency. The roll clearance was set at 0.012 in. for the first 60 min. and then changed to 0.006 in. for the remainder of the beating cycle. Samples of 2500 ml. were removed at intervals of 30 min. for a total beating cycle of 180 min. After beating, 60-lb. (24 × 36—500) handsheets were formed on the Noble and Wood sheet machine, pressed to 31–33% moisture and dried at 240°F. on the drier drum to 3–5% moisture.

Use of the Valley beater for work of this nature has two very distinct limitations. The mechanical action of the beater is governed by the weights applied to the bed plate and sharpness of the bed plate and roll. Using the Valley beater it is very hard to duplicate freeness changes or degrees of beating accurately because each sample of stock will have the inherent differences of pulp quality previously mentioned. Also, there is the possibility that as the beater is used repeatedly, the characteristics of the roll and bed plate are subject to change through dulling or sharpening. A second

Table II. Dilts Beater

Cook no.	Tensile 20	30	40	50	60	70	80
	Tear 20	30	40	50	60	70	80
717	177	273	400	387	352	314	
718	313	381	412	396	344	300	
719	305	393	417	392	362	316	
720	233	327	388	382	351	300	
721	312	350	377	391	382	307	
722	260	388	485	440	375	324	
723	258	386	402	362	313	275	
724	268	392	385	358	328	276	
725	260	333	350	332	310	..	
726	292	401	420	375	328	282	
727	277	328	318	300	278	..	
728	275	329	310	295	277	255	
Average [mean]	270	357	389	368	334	295	
Standard deviation of single reading	38.1	39.6	47.3	41.6	34.5	22.3	
Standard deviation of mean	11.0	11.4	13.7	12.0	10.0	7.1	
Confidence limits on the mean	24.2	25.1	30.2	26.4	22.0	22.5	

limitation of the Valley beater is the amount of stock available in the beater from which samples for test may be removed. Also, of necessity, these samples will have to be of small quantities so that a sufficient number of samples can be tested to accurately describe the action taking place. Use of these small samples limits the number of handsheets which can be produced.

The Dilts beater has the limitation of not being able to accurately reproduce freeness curves due to (1) the inherent differences in pulp quality present in each cook and (2), to inaccuracy in setting of the roll clearance and keeping this clearance setting stable.

The limitations of the two beaters I have mentioned caused us to look for a relationship of the physical tests which would be independent of freeness drop or beating time in the final outcome.

The results of each test were first plotted in the usual manner of tear, tensile, and freeness against beating time. Due to the different time cycles involved, these plots are of no value in a direct comparison of the two beaters. However, it was possible from these data plots to obtain values of tear at various levels of tensile development. From a plot of these tear tests versus tensile tests we were able to describe for either beater a simple single curve of the pulp quality independent of beating times or freeness values.

Table I is a tabulation of the tear tests for various levels of tensile development for the Valley beater. A similar tabulation of results was made for the Dilts beater. Listed in order of cooking, the tear tests for each tensile test level were collected and standard deviations of individual tests, standard deviations of the mean, and 95% confidence limits on the mean were calculated.

Table II is the tabulation of results for the Dilts beater. The collection and calculation procedures are identical to the ones used for the Valley beater. It is interesting to note that the standard deviation of the means for both beaters indicate if these tests were run again, it is possible the averages would shift considerably.

The means of the tear tensile relationships and their confidence limits were plotted to show visually whether the apparent difference between beaters could occur by chance or whether there is a significant variation due to the beaters.

In Fig. 1 the solid lines represent the mean, upper, and lower confidence limits for Dilts beater tear-tensile relationships and the dotted lines represent the mean, upper, and lower confidence limits for the Valley beater tear-tensile relationships. As can be seen, the confidence limits of the two means overlap to such a degree that the apparent difference between beaters must have occurred by chance.

Based on any reasonable number of tests we can safely conclude variations of results of tests derived from procedures utilizing different beaters will occur by chance if the same sheetmaking facilities and testing procedures are used.

It is also apparent, from examination of the results, that there is wider deviation from the average with the use of the Valley beater than when the Dilts beater is used. This is possibly due to the limitations previously mentioned.

After examination of the wide range of values obtained for the test results and the accompanying standard deviations of individuals and means it is suggested that sufficient samples be tested to compensate for wild test values that will occur. This will insure a valid estimate of the pulp quality.

A second testing procedure was devised while developing this tear-tensile relationship. It was noted in projects such as our outside chip storage series, the use of tear-tensile relationships in comparing a series of six separate sample periods any single graph of these curves would be too cluttered to understand easily. Therefore, we have expressed the pulp quality for each sample period in the form of one number which we call the strength factor. The strength factor was calculated by first obtaining the product of tear times tensile from the graphs of tear versus tensile at tensile increments of 5% from 20 to 65% tensile. These products were then averaged and plotted versus storage time. Corresponding calculations were carried out on the upper and lower confidence limits curves. This strength factor along with 95% confidence limits around it can then be plotted on a bar graph with other sample period relationships to give an overall description of pulp quality development in an extended storage period.

Presented at the meeting of the Gulf Coast Section of TAPPI, held in New Orleans, La., May 13, 1960.

A Modified Chlorine Number Apparatus

Baynard L. Malone

MAINTENANCE difficulties with the Roe chlorine number apparatus is probably one of the main reasons for the lack of general acceptance of this test in routine mill analysis programs.

Specifically, there have been two main problems: first gas leaks caused by deteriorating hose connections, and second, freezing stopcocks. Not only do these two difficulties cause lost samples and time, they also tend to reduce the reliability of results.

In 1957 Beazley, Herbst, and Histed (*1*) of Industrial Cellulose Research, Ltd., described an improved apparatus and modified test procedure for the Roe chlorine number. Briefly, these improvements consisted of substituting ball glass joints for hose connections, using Kel-F fluorocarbon grease as a stopcock lubricant and changing the relative volumes of the various components in order that a pure atmosphere of chlorine could be maintained in the reaction chamber during the entire test. Data were also presented showing the effect of light on chlorine consumption and a correlation between pulp moisture and the blank.

At the St. Joe Paper Co. we were also prompted to modify difficulties with the standard apparatus. Our old apparatus was essentially TAPPI Standard T 202 m-45 construction and had been in routine use for several years. Modifications included some of the features described by Beazley (*1*) along with ideas of our own.

The St. Joe apparatus was fabricated from pyrex glass components connected by fused pyrex tubing to form a single piece unit. The basic apparatus was compact enough to be housed in a 6 by 8 by 34-in. vertical cabinet with the leveling bulb and gas cylinder outside. Teflon plug stopcocks, requiring little or no lubrication, were used in place of glass. This apparatus was designed to test the standard 2-g. sample of pulp for chlorine numbers up to approximately 26. In cases where stock is predominately low yield the gas buret should be redesigned to fit conditions.

The St. Joe apparatus is used for hourly routine testing of third-stage stock and has given practically trouble-free service for the past two years. The apparatus is cleaned, on a routine basis, once each week (about 170 tests) and takes only 30 min. The only breakage in the past two years has been the detachable reaction chamber caps on the original apparatus. We are now using a solid teflon cap which has been very satisfactory for routine work. The teflon cap absorbs a small amount of chlorine each test and is allowed for in the blank. We have had no trouble training nontechnical personnel to operate this equipment and, as I mentioned before, there has been no history of serious breakage.

The fabrication cost of the basis unit is approximately twice the cost of individual components. Considering the savings of maintenance time, lost time, and increased reliability of results we feel that this extra investment has been justified.

APPARATUS DETAILS

The St. Joe apparatus is similar to the TAPPI Standard T 202 m-45 in that it contains the same component parts,

BAYNARD L. MALONE, Process Chemist, St. Joe Paper Co., Port St. Joe, Fla.

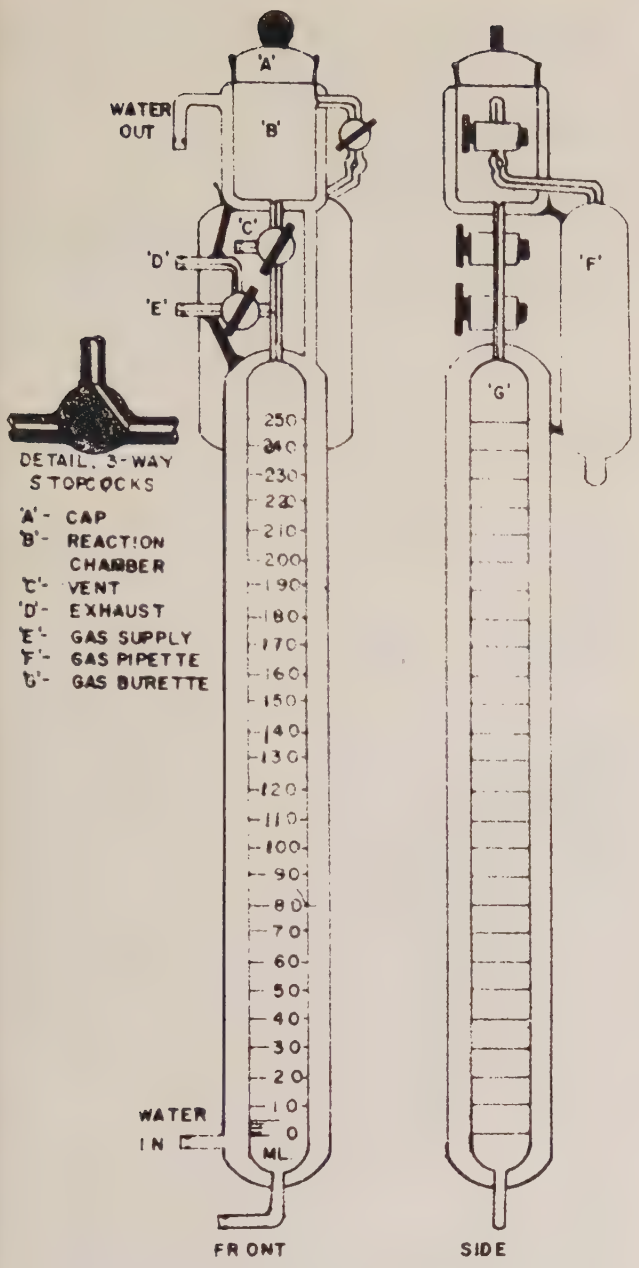


Fig. 1. The St. Joe modified Roe chlorine number apparatus

i.e., reaction chamber, gas pipet, gas buret, stopcocks, and water jacket.

As illustrated in Fig. 1, the component parts of the St. Joe modification are connected by capillary glass tubing made as short as spacing allowed. The reaction chamber is located directly above the gas buret with water jackets connected in series. The gas pipet, placed directly behind the space between the reaction chamber and gas buret, serves an additional function of adding strength to the unit.

As noted by Beazley (*1*), the gas buret should have capacity to displace all air in the reaction chamber and still have chlorine left for a complete reaction with the sample. In addition the gas pipet should be large enough to contain the reaction chamber volume in one half of one leg of the pipet. The foregoing conditions are met in the design of the St. Joe apparatus with a 290-ml. gas buret (graduated 0–250 ml.), 55-ml. reaction chamber (80 ml. less 25 ml. for teflon basket), and a 300-ml. total volume, gas pipet.

The apparatus cabinet is constructed of $^3/_4$-in. plywood weighted in the bottom with $^1/_8$-in. boiler plate. Two laboratory type clamps were adapted for mounting on the back of the cabinet, and hold the glass unit in place by clamping

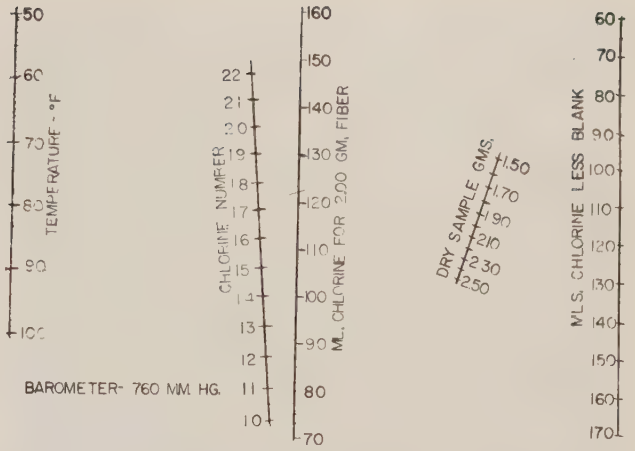


Fig. 2. Nomograph for calculating the Roe chlorine number

the lower water jacket. The weight of the glass is carried by a rubber cushion under the lower water jacket. Flexframe laboratory rod and fittings are attached to the outside of the cabinet to support the leveling bulb. A standard 15-lb. chlorine cylinder with needle valve is attached to the apparatus with neoprene hose. A black cloth cover is provided to darken the reaction chamber during the test.

OPERATION

Our test procedure is similar to the TAPPI Standard T 202 m-45 except for the method of sample preparation. A uniform pulp pad of 4 to $4^1/_2$ g. is formed in a 12.5-cm. Buchner funnel and pressed to a uniform consistency between blotters in a clothes-type wringer. Half of the pad, without drying, is used in the chlorine apparatus and half for consistency. During the test the sample is contained in a removable teflon basket which prevents pulp from accumulating in the reaction chamber. Kel-F fluorocarbon grease is used on the reaction chamber cap joint as a positive seal and

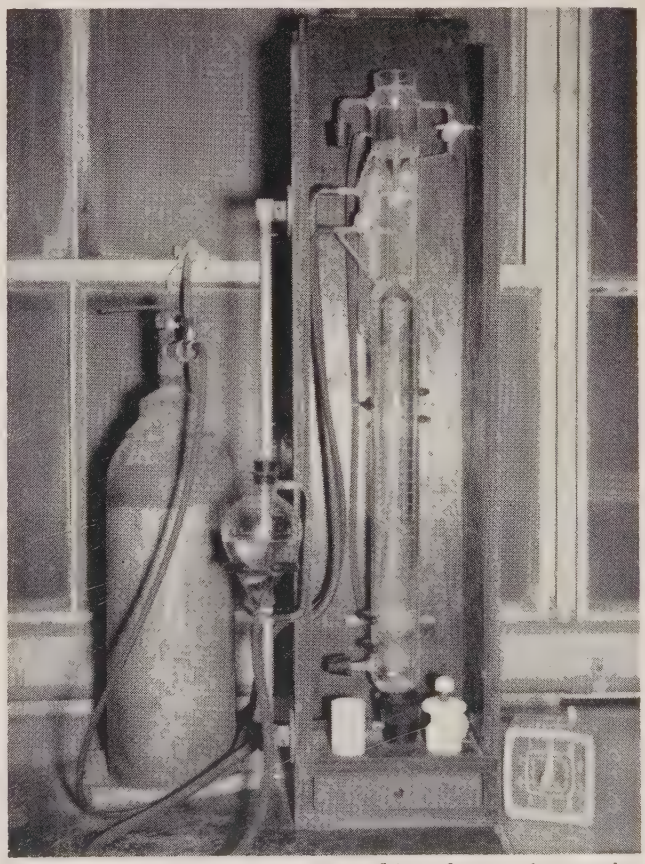


Fig. 3. Apparatus mounted in cabinet for routine testing

to prevent sticking. A small amount of Kel-F is also used on the stopcocks.

Calculation of the chlorine number is made with the aid of a nomograph as illustrated in Fig. 2. Actual size of a nomograph is approximately 25 by 18 in. A low-range nomograph, not shown, is used for chlorine numbers from 3.5 to 10.5. The nomograph is based on a 760 mm. barometric pressure. Our errors in chlorine numbers caused by changes in barometer are usually small and are neglected in routine testing. The following formula may be used if a correction is necessary:

$$\text{Chlorine no., corrected} = \frac{\text{actual mm. Hg}}{760} \times \text{(chlorine no., from nomograph)}$$

At the present time the St. Joe Paper Co. has three units similar to the one described. One in routine use for third stage pulp, one in our development laboratory, and one spare. The St. Joe Paper Co. has been using the Roe chlorine number in pulp evaluation since 1952 and we feel that at the present time it is the most reliable and convenient test for measuring pulp hardness.

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Kalamazoo Valley

March 17, 1960 Meeting

"Graphic Arts" was the subject of the fifty meeting of the Kalamazoo Valley Section. This was a joint meeting with the Michigan Division of PIMA and the southwestern Michigan chapter of Printinghouse Craftsmen. John Tongren, program chairman, stated, "This is something of a milestone. TAPPI and PIMA have worked together a long time and now they are joined by the Printinghouse Craftsmen."

An afternoon attendance of about one hundred was present at Inman's Restaurant on March 17, 1960, to hear Miss Jacqueline M. Fetsko of the National Printing Ink Research Institute, Lehigh University, Bethlehem, Pa., and Clair Donovan of the Wheeler Van Label Co., Grand Rapids, Mich. Miss Fetsko's topic was "Fundamentals of Printing"; Mr. Donovan's was "Pipe Dreams of a Printer." A movie, "Watercolor and Printers' Ink," from the film library of the Ford Motor Co., was also shown. The papers follow this report.

After dinner Lony Ruhmann of the Container Corp. of America, entertained and educated the audience (which had grown to 186 persons) with his talk on "Design and Color in Packaging."

April 21, 1960 Meeting

Inman's Restaurant, Galesburg, Mich., was the scene of the sixth meeting of the season for the Kalamazoo Valley Section on April 21, 1960.

Program chairman for the meeting was Glenn Touse who presented Dr. E. E. Dickey of The Institute of Paper Chemistry to an audience of 85 members. Dr. Dickey's paper, "The Role Of Hemicelluloses in Pulp Behavior, follows this report.

May 12, 1960 Meeting

A total attendance of 136, including 23 senior students and faculty guests from Western Michigan University, attended the joint Michigan Division of PIMA and Kalamazoo Valley—TAPPI "Recognition Night" at Gull Harbor Inn, Richland, Mich., on May 12, 1960. E. E. Stephenson, past chairman of Kalamazoo TAPPI, presided over the meeting.

Unaminous approval by the membership was given to the slate of officers and executive committee for TAPPI submitted by the Nominating Committee, Paul Applegate, chairman:

Chairman: W. L. Kite, Simpson Lee Paper Co.
Vice-Chairman: J. D. Chadderdon, KVP-Sutherland Paper Co.
Secretary: Arthur Hupp, Watervliet Paper Co.
Treasurer: Harry Parker, Hodag Chemical Corp.
Executive Committee: W. O. Kroeschell, Michigan Carton Co. Gordon J. Gill, Penick and Ford Ltd.; Andreas Von Koeppen, Western Michigan University; Robert W. Hagemeyer, Wyandotte Chemical Co.; Martin A. Craig, Dow Chemical Co.; R. M. Levy, Allied Paper Corp.; W. R. Noel, Kalamazoo Paper Co.; Howard H. Parker, Hercules Powder Co.; John C. Tongren, Watervliet Paper Co.; Richard Van Buren, J. M. Huber Corp.

Also elected by unanimous consent were the new officers of PIMA as proposed by the Nominating Committee, Ray Barton, chairman:

Chairman: L. B. Owens, Allied Paper Corp.
1st Vice-Chairman: Preston D. Carter, KVP-Sutherland Paper Co.
2nd Vice-Chairman: Gordon Morseth, Rochester Paper Co.
Secretary-Treasurer: Dr. John Fanselow, Western Michigan Univ.

W. O. Kroeschell of TAPPI and E. M. Baker of PIMA were honored as past chairmen and will receive past chairman's awards.

Raymond Janes, Western Michigan University, presented the annual award of the WMU Paper Technology Alumni Association to Edwin C. Abbott of Montreal, Canada, as the outstanding senior student this year. This award consists of a set of TAPPI Standard and Data Sheets plus the engraving of the recipient's name on a permanent plaque at the Paper Department of the University.

The three seniors of Western Michigan University who won the Kalamazoo Valley TAPPI Research Award for 1959–60 also presented their winning papers. First place was won by Ralph Herrick. His topic was "Cold Caustic Soda Pulp from Aspen Wood—Some Facts on the Material Dissolved by the Process." By use of paper chromatography, Mr. Herrick determined the materials, and their amounts, present in unpulped and pulped aspenwood and by difference found the materials removed and the amount removed. Second prize winner, Tachipully Bhaskaran, in his paper "Cold Caustic Soda Pulp Produced from *Eucalyptus saligna*" investigated the optimum cooking conditions for the wood and compared the results with aspen produced by the same process. "A Quantitative Investigation of the Effect of Cutting and Fibrillation on Certain Paper Properties" won third prize for Edwin Abbott. Abbott in his work sought the effect of adding controlled amounts of highly fibrillated and highly cut pulps to a standard pulp in regards to basic sheet strength properties.

W. L. Kite, *Secretary*

Fundamentals of Printing

Jacqueline M. Fetsko

The dictionary defines fundamentals in many ways, some of which are related to geology, others to acoustics. For the purposes of this discussion three of the definitions are appropriate: essential, truth, and basis. The essentials of printing will not be taken up here, for it is well known what they are: press, paper, ink, and people. The second definition, truth, is of paramount importance. What is the truth? What are the facts? The true facts are readily ascertained merely by making numerical measurements as opposed to deriving opinions from experience in the art. Indeed, the purpose of this discussion is to show how several such popular notions were unfounded simply through the process of taking appropriate measurements.

Jacqueline M. Fetsko, Supervisor of Printing Research, Lehigh University, Bethlehem, Pa.

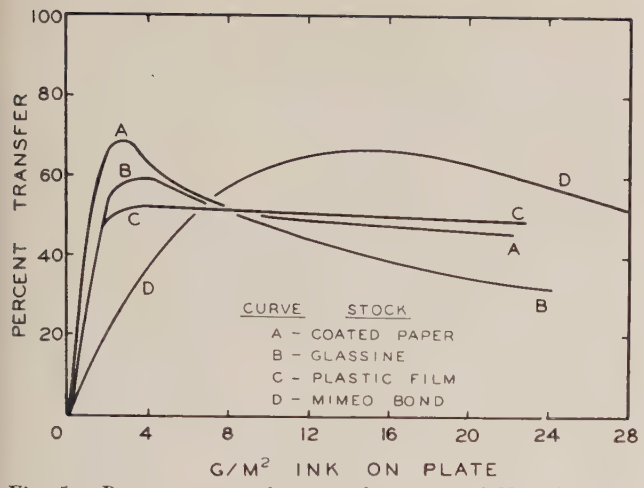


Fig. 1. Per cent transfer as a function of film thickness originally on the plate for one ink printed on several stocks

It would be futile, however, to go on taking measurements and collecting data indefinitely. Here is where the third definition of fundamentals comes in, basis. What is the basis for the trends? What are the reasons for the facts? Only by relating the facts to their reasons can we obtain a true understanding of the variables important in printing. Only in this way can progress be made toward elevating printing from the realm of an art to that of a science. Even if a better printed product does not result (which is hardly likely), the psychological impact on the graphic arts worker must be considered; a person who understands the reasons for problems must certainly be happier and more interested in his job than one who stands by with little idea of what is actually going on.

This discussion will therefore not only show how popular notions were unfounded, but also how investigating the reasons for the facts led to new concepts of the mechanisms involved in printing. It should be emphasized that facts seldom can be argued with, but there may be great differences of opinion regarding the reasons for the facts. Two preconceived notions which were disproved by taking appropriate measurements are concerned with transfer and two are concerned with print quality.

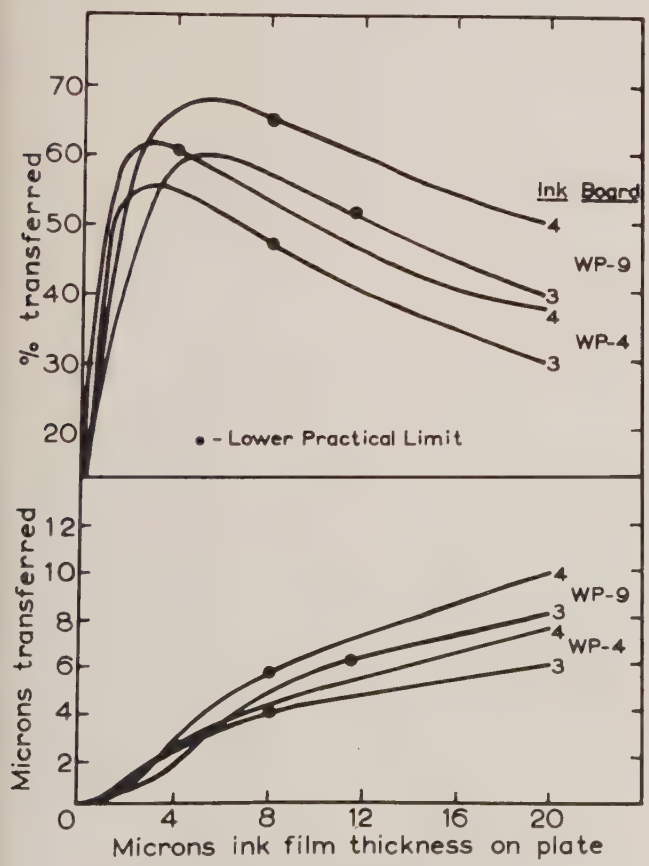
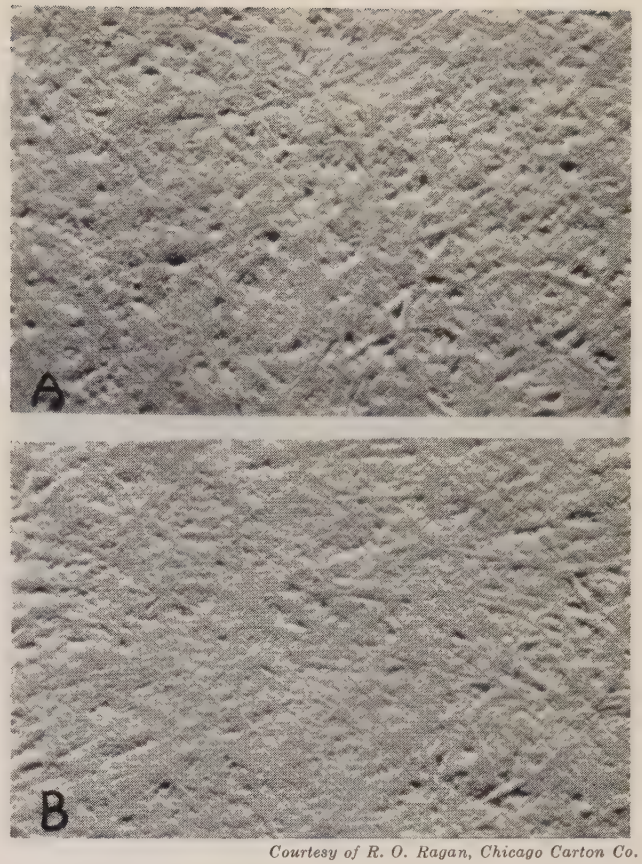


Fig. 2. Transfer characteristics of two white patent coated paperboards printed with two inks



Courtesy of R. O. Ragan, Chicago Carton Co.

Fig. 3. Surface photomicrographs of solid bleached paperboards, 23×. A—regular, B—sized

Notion 1. Fifty Per Cent of the Ink on the Plate Transfers to the Paper. Upon measuring ink transfer, it was noted that per cent transfer is seldom 50%, but is highly dependent on the ink film thickness on the plate. Figure 1 shows this situation for one ink printed on several types of stocks (*1*). While the 50% transfer concept applies to the plastic film, the situation is entirely different for most printing surfaces. Going from low to high ink film thicknesses, transfer increases from zero, reaches a maximum which may be as high as 60 or 70% (and higher in other cases), and then decreases to a leveling off point at high ink film thicknesses. Coated stocks usually have a sharp peak at a relatively low film thickness and a leveling off point of about 40%. The curve

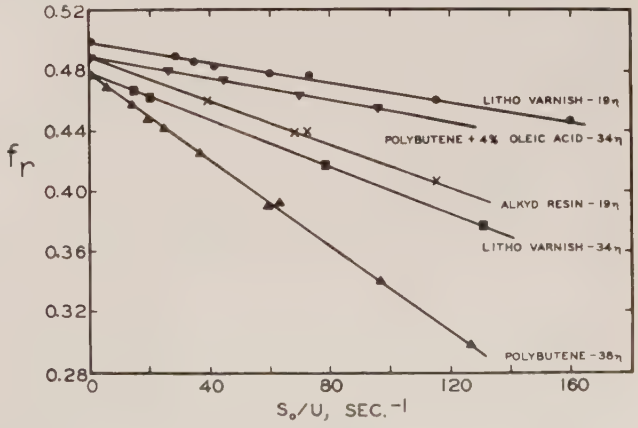


Fig. 4. Film split during printing versus shortness of black inks

for glassine, which was a porous type, leveled off close to 30%, as is also the case for many paperboards studied. The high wide peak of the mimeo bond is representative of newsprint.

The general transfer curve shapes illustrated in Fig. 1 has been confirmed by research workers throughout the world. Further studies have shown that the curve shape also depends on the type of ink, printing pressure, printing speed, etc., so that it can be said that there is a characteristic curve shape for each combination of stock, ink, and printing conditions.

Hundreds of such transfer curves have been obtained. Even when stocks within one class are compared, the order in which the stocks are ranked for transfer changes at different ink film thicknesses; such reversals make it rather difficult to describe the results of the measurements. A typical situation is shown in Fig. 2 for two inks printed on two white patent coated paperboards (*2*). The bottom of this figure illustrates that, contrary to the per cent transfer curve shape, the amount transferred always increases with increasing ink film thickness.

The reasons for the rise and fall in the percent transfer curve were the object of considerable attention in our laboratory. It is to be remembered that, if transfer is understood, we are then at the root of the entire printing process. The analysis of the transfer curve shape led to the hypothesis that, in the thin ink-film-region, there is insufficient ink to cover all the smoothness defects on the stock surface, consequently transfer at first is very low but rises as the ink film increases. The reason why the curve reaches a maximum and then falls (rather than levels off) is attributed to the hypothesis that two stages are involved in the transfer process. One stage involves ink absorbed or immobilized by the stock during the brief dwell time. The other stage involves the split of the ink between the plate and the stock.

Based on this physical model, an equation was fit to the transfer data (*3*). It then became possible to describe the transfer characteristics of an ink-paper-press combination in terms of three numerical constants related to the three phenomena controlling transfer; smoothness, instantaneous absorption, and film split.

The transfer constant for printing smoothness, called k, was of immediate practical value. For many years smoothness of paper had been evaluated with empirical measurements such as air flow and the like. Such measurements were never used with very much confidence because it was not known how meaningful they were. The transfer constant k permitted smoothness to be characterized under actual printing conditions, but due to the length of time required to perform the transfer measurements and the calculations this technique was of interest only in research. The next logical step was to use the k measurements as the referee against which other empirical test measurements could be compared.

Two such correlation studies were undertaken (*2*, *4*) and it was indeed found that the conventional smoothness tests are of limited value particularly for rating stocks of different types. The best test appeared to be surface photomicrographs; not only did they correlate best with printing smoothness but they also give a good pictorial description of the surface contour. Figure 3 illustrates photomicrographs of two paperboards. The photomicrographs brought out some interesting points. Roughness occurring as holes is more deleterious than hills. The reason is undoubtedly that hills can be compressed under printing pressure. It is expected that cavities would be particularly harmful in halftone printing.

In a similar vein, the other two constants are being studied to elucidate the mechanism of transfer. For the first time it is possible to separate the ink transferred due to immediate penetration from that due to ink splitting. In this way, it has already been established, for example, that after full contact is achieved, the majority of the ink that transfers to a relatively nonporous surface such as a coated paper is due to ink splitting; on the other hand the majority of the ink which transfers to more porous stocks such as uncoated papers and paperboards is due to instantaneous absorption.

Thus, not only did the simple task of taking measurements disprove preconceived notions about how much ink transfers, but it also led to the development of a mechanism whereby ink transfers. The factors controlling transfer can now be studied independently of each other and related to the effects of ink, stock, and printing conditions.

Notion 2. Rheological Measurements of Inks Will Not Correlate with Their Printing Behavior Because the Shears Available in Viscometers Are Much Too Low Compared to Those Which Occur During Printing. Despite the seeming hopelessness of such an investigation, a study was nevertheless undertaken to establish whether a correlation existed between rheological measurements of inks and their splitting behavior during printing (*5*). This study was made possible through the transfer constant for film split, which is called f. Figure 4 shows the film split during printing plotted against the rheological property referred to as "shortness" of a series of inks. For the cases illustrated, one pigment was dispersed in several vehicles. Note that each vehicle system gave a separate line; the points on each line represent different pigment loadings in the respective vehicles. Further studies showed that each pigment type also gives a separate line (*6*). It can be noted in Figure 4 that, at any particular measured value of shortness, the film split will vary greatly depending on the nature of the ingredients. This study therefore disproved the popular notion that, although the 50% total transfer concept was conceded to be false, the ink itself should split at 50%. Note in Fig. 4 that this concept is also false; at 120 sec.$^{-1}$ for example, the split of the inks ranged from 29 to 46% for the cases illustrated.

The conclusion derived from this study was that rheological measurements will predict splitting behavior of inks but only if the inks contain the same ingredients. Previously reported lack of correlation is now explained on the basis that inks containing different ingredients might have been compared.

The finding that low shear viscometer measurements correlated at all with printing behavior was of great fundamental importance, because it indicated that low shears may also exist together with high shears in a press nip. Theories of nip behavior under study by the rheology and dispersion groups at Lehigh (*7*, *8*) confirmed this indication. Their concept of nip behavior is diagramed in Fig. 5. Note first of all the pressure profile at the top of the diagram. The pressure is at a maximum at the beginning of the nip where the plate and paper meet. Here, another popular notion was disproved; at one time it had been thought that the pressure maximum is at the center of the nip. The center maximum applies in platen printing, but it is now certain that whenever one or more rotating cylinders are involved, the pressure maximum shifts to the beginning of the nip, and drops to below zero at the end of the nip. This pressure rise and fall produces a pumping action which forces more ink through the nip than clearances would suggest. It may also explain why the leading edge of a print usually is sharper than the trailing edge.

The falling pressure creates shear patterns through the center of the nip. While the shear may be tremendous in the center region, it can be noted that there are two zones of zero shear, one at either end of the nip region. Thus the ink goes from zero shear to very great shears and is again returned to zero shear in a fraction of a second. The existence of the zero shear region just prior to where the film splits is used as the basis for explaining why low shear viscometer measurements correlated at all with film splitting behavior.

Notion 3. The Cause of Mottle Is Too Much Ink. This statement was once made by an "expert" in answer to a question about causes of mottle. (By mottle is meant the nonuniform appearance of a print having adequate ink coverage;

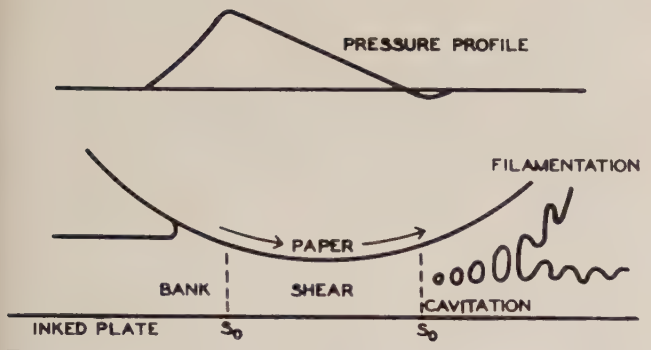


Fig. 5. Pressure profile and shear regions in a press nip

it is not to be confused with nonuniformity caused by lack of coverage.)

The prints made in controlled printing studies were then carefully examined, and it was observed that, in some cases, mottle occurred with hardly enough ink to produce full coverage, while in other cases mottle did not occur even at exceedingly high ink film thicknesses. It was true, however that when an ink-paper combination tended to mottle, the mottle increased in scale and severity with increasing ink film thickness, but it was very apparent that too much ink film thickness itself was not the major cause. Further studies showed that mottle increased at higher pressures and with slower press speeds. The influence of speed was particularly dramatic; differences in lay noted between proof press and production press prints may well be explained on the basis of differences in printing speeds. It was also found that printing from a rubber plate instead of a metal plate greatly reduced mottle. Other studies showed that different types of mottle occurred on various stocks. On many smooth coated stocks, the mottle pattern assumed a regular periodicity; on many uncoated stocks, the mottle pattern consisted of randomly spaced shiny and dull or dark and light areas.

Here again, the observations, which unfortunately are not numerical because of a lack of a mottle test instrument, led to an hypothesis on why mottle occurs. Mottle is obviously the result of nonuniform ink film thicknesses on the surface of the sheet. The reasons for the nonuniform film thicknesses are thought to be ink filamentation and absorption. First of all, the ink splits between the plate and the paper not as a uniform sheet, but rather as a series of filaments. Figure 6 shows such filaments. Secondly, the ink filaments are deposited on the surface of the sheet which is itself not uniform, but rough in varying degrees as was illustrated in Fig. 3. After reaching the paper surface, the nonuniform mounds of ink can do one of two things. They can sit there essentially

Courtesy of O. G. Linnell, R. R. Donnelley and Sons Co.

Fig. 6. Splitting of ink filaments between two rollers

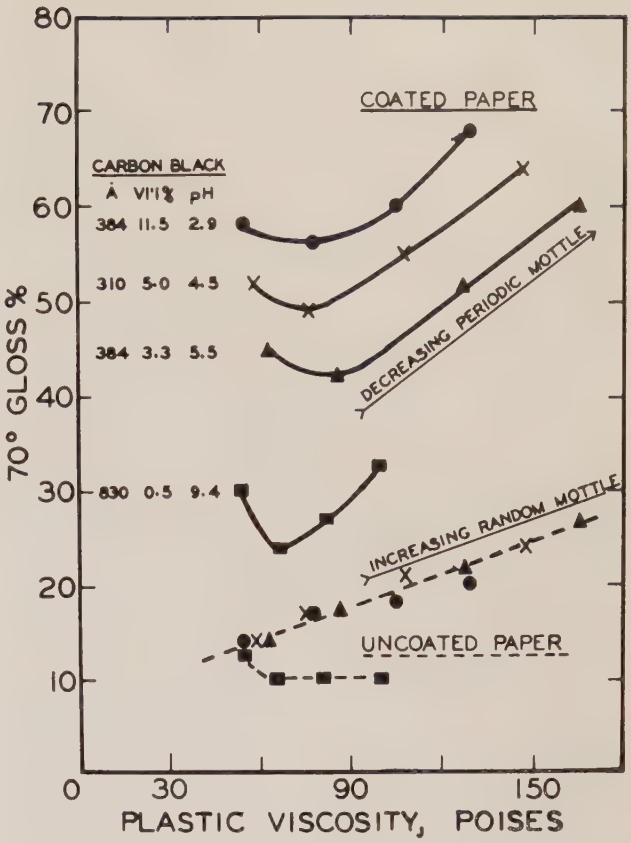


Fig. 7. Print gloss versus viscosity of black inks

as they were formed; in this case the mottle pattern has a regular periodicity such as is frequently observed on smooth relatively nonabsorbent coated papers. The second alternative is for the ink filaments is to be disturbed; this is evidently the case when sufficient vehicle penetrates into the sheet. If, however, the penetration is not uniform, random shiny and dull spots will occur. These random shiny and dull spots may form a fine pattern on relatively well-formed sheets such as machine coated paper, but on poorly formed sheets the scale of random and shiny spots may be quite large and objectionable. Another factor is the sensitivity of the ink to the variations in pore structure on the surface of the sheet.

It is interesting to note that the filamentation aspect of mottle is directly related to the concept of nip behavior mentioned previously. Returning to Fig. 5, it can be seen that, at the end of the nip where the plate and paper separate, the ink film can no longer fill the space between them. First cavities or air bubbles within the film form; these expand and grow larger until they coalesce and finally form the filaments which are drawn out until they break. The cavitation formation and growth stages are under concentrated study in our rheology laboratory in order that the factors controlling them may be elucidated. It is currently thought that a large number of small bubbles at the rupture point will produce small filaments which are not readily visible on the print. On the other hand, a small number of large bubbles at the rupture point would tend to produce large filaments and to enhance the mottle pattern. It is believed that ink film thickness, pressure, and speed influence filament size through their influence on the pressures and shears which are created in the nip and the reaction of the ink to these factors.

Notion 4. Print Gloss Is Primarily a Matter of Penetration. On this basis it would be expected that inks containing thin vehicles would produce flatter prints than inks containing heavy vehicles. Upon examining a set of gloss holdout results, it was noted that, contrary to expectations, gloss actually decreased with increasing vehicle viscosity (*9*).

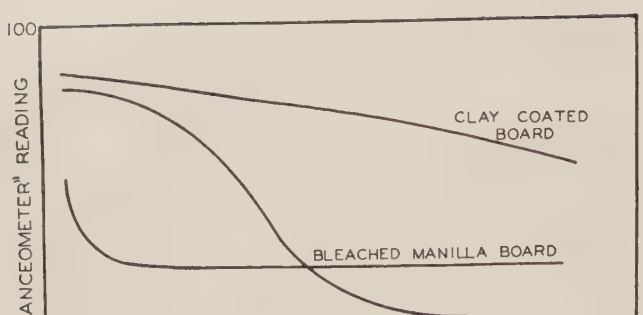


Fig. 8. Penetration of oil into various paperboards as a function of time

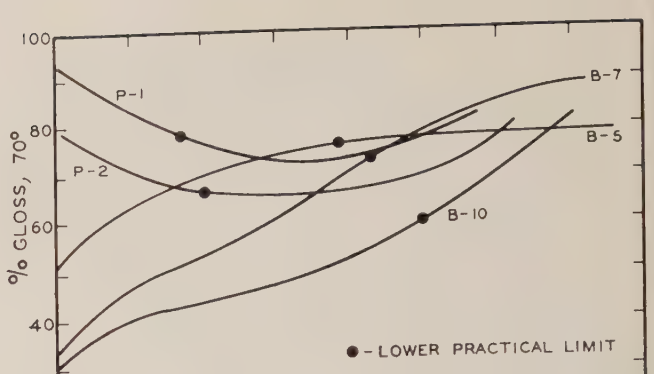


Fig. 9. Gloss versus ink film thickness on the print

P–1, P–2—glossy coated papers. B–5—clay coated paperboard. B–7, B–10—uncoated paperboards.

Close examination of the ink formulation revealed that the ink with the thinnest vehicle viscosity also has the highest pigment loading. Since this ink gave the highest gloss holdout, it was hypothesized that the large number of pigment particles in the ink formed a network of fine capillaries which tended to hold the vehicle on the surface of the paper rather than release it for penetration into the stock. Thus it became apparent that vehicle retention by the ink must be an important aspect of the gloss holdout mechanism.

Further studies with a systematic series of inks tended to support this hypothesis, (*6*). Figure 7 shows the situation when 16 black inks were printed on a coated and on an uncoated paper. These inks were composed of four carbon blacks dispersed at four different loadings in a lithographic varnish. On the uncoated paper, gloss increased directly with increasing ink viscosity for three of the four pigments. On the coated paper, however, each pigment gave a separate gloss-viscosity relationship. It might be expected that the smallest particle size would produce the best gloss levels, but note that two pigments of the same particle size gave entirely different glass levels. In the cases illustrated there was a good correlation with volatile matter on the surface of the pigment, and also with pigment pH. Such properties could influence capillarity indirectly through their influence on wettability. It had been observed, for example, that the pigment with the highest volatile matter seemed to wet down faster during the premix operation.

It is quite evident from these examples that gloss is a complicated matter which involves the ingredients in the ink as well as the type of paper printed. The situation is particularly complicated with papers having a double pore structure, which is usually produced by coating or extensive calendaring; in such cases the setting up time of the ink is critical. For example, in one study it was found that the order in which the stocks were ranked for gloss tendency differed from ink to ink (*4*). The causes were traced to the different drying times of the inks coupled with the coating thickness on some of the stocks. The complete "Vanceometer" curves in Fig. 8 provide a graphic illustration of this interrelationship. Note the slow penetration into the clay coated board, the initially slow and the subsequent fast rate of penetration into the sized sulfate board and the immediately fast drainage into the bleached manilla board. Furthermore, the early time "Vanceometer" readings correlated with print gloss a fast drying ink, while the long time readings correlated with print gloss from a slow drying ink.

The physical model of the gloss holdout mechanism which was derived therefrom is that the penetration aspects of gloss holdout involve a balance between the pore structure of the sheet and the setting time of the ink. Other properties are the smoothness of the sheet itself and its base gloss. Since so many complicated factors are involved in the development of gloss, it is obviously impossible to rely upon any single physical test measurement whether on the ink or on the stock to predict gloss. Currently the most reliable method is actual printing, but great care must be taken that the results are comparable. Ink film thickness, for example, must be carefully controlled. Figure 9 shows gloss as a function of film thickness for one ink printed on various stocks. It can be noted that the stocks would be ranked in entirely different orders for gloss tendency depending on the ink film thickness taken for comparison. Similar reversals were noted when several inks were printed on one paper. For these reasons, gloss should be compared at known film thicknesses and also at several ink film thicknesses to detect changes in trends. The use of a wedge-type printing plate is recommended to facilitate press testing at a variety of controlled film thickness (*10*).

In conclusion, it has been shown that several popular misconceptions were disproved when appropriate measurements were made. The results of such studies also led to proposed mechanisms on which were based explanations for the observed trends. It should be emphasized again that acceptance of the facts does not necessarily imply acceptance of the proposed reasons.

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Presented at the meeting of the Kalamazoo Valley Section of TAPPI, held in Galesburg, Mich., March 17, 1960.

Pipe Dreams of a Printer

C. M. Donovan

A RECENT series of six articles in *Printing Production Magazine* by Marvin Rogers provided an interesting study of the current status of research and technical development within the industry. This series discusses the failings of the present unorganized system and the lack of any significant coordinated general effort among the various elements. A

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few bright lights show up. These include the work of the Time, Inc., Springdale Laboratory, and some of the work done by L.T.F., A.N.P.A., P.I.R.I., Battelle, and foreign work in Holland and Great Britain. Any correlation between the relative size of the industry and the amount of funds devoted to research is missing. After examining the situation, Dr. Rogers proposes that all segments of the industry support the establishment of a centralized general research center which would attack the basic problems and processes common to all the methods of printing. The target would be general improvement through simplification, consolidation, and innovation in the fields of raw materials, methods, and equipment. Perhaps such a proposal assumes a more altruistic attitude on the part of potential participants than actually exists—but the idea points in a direction which must be followed.

Dr. Roger's ideas are thought provoking and exerted considerable influence upon my thinking for this St. Patrick's Day meeting. My thoughts here are possibly a sort of "brain-storming game of solitaire" and should be considered in the light of this approach. My hope is that many of you who may be in a position to influence the developmental direction of the paper industry will find enough stimulation to provoke some personal "brain-storming" way out in left field.

The current status of all of the major printing techniques shows trends toward improvement which are a direct result of the application of research and engineering knowledge to improvement in raw materials, methods, and machinery. Some of these changes are as follows:

First. The retreat of the flat-bed press and the advancement of rotary machines for printing from large, multiple image direct printing plate segments or wrap-around flexible direct printing plates is revitalizing the letterpress interest.

Second. Increased usage of web fed machines in offset, letterpress, gravure, and flexographic printing is promoting more economical costs through savings in paper cost and press time.

Third. The use of forced drying systems on all the major printing methods is boosting quality and speed but imposing stringent demands on papermakers and ink manufacturers.

Fourth. Continued interest in means for reducing setup procedure time through prepress improvements in speeding service and production.

Fifth. Printers are steadily abandoning the rule-of-thumb methods for control of attributes which once dominated the industry and turning to the use of positively instrumented control of variables for quality. The use of pH meters, densitometers, tack-reading inkometers, moisture-level meters, microscopes, viscometers, and other accurate and reproducible instruments for control are rapidly becoming commonplace.

This last item involves a major area of improvement. In order to help the craftsman abandon his dependence on his own senses and experience to control the process, the various attributes which he examines, judges, and acts upon must be studied in the light of their variation between and around his "go" or "no go" judgment. When a pattern of variation has been established, instrumentation must be developed and standards set up in order that the variable may be specified at a given level and controlled within tolerances.

At present the printer must work around paper and its ever-present characteristic of grain or definitely oriented properties. He must constantly face the problems of printability and the somewhat related problems of ink drying and adhesion, print smoothness, and multicolor wet ink trapping. His sheet fed presses are complicated by an elaborate system for elevating, separating, conveying, guiding, detecting, transferring, and delivering the work in sheet form. Many printers find that air-conditioning is necessary for better control of paper mechanical stability during printing. Almost all letterpress and offset printers find themselves spraying a material of some sort between printed sheets to avoid spoiling the printed surface. Coated papers must be watched carefully to avoid picking problems.

In addition to the paper problems the printer is also confronted with control of body, tack, color strength, and drying characteristics of ink. The gravure printer tries to balance viscosity maintenance versus flow versus drying time on high-speed web machines. Generally, the printer becomes an "ink expert," well versed in all the means for ink manipulation to help save the job and get the most out of the ink paper relationship.

What are the prospects for continued change and improvement in the future? Among the possibilities for specific printing methods might be listed some of the following:

Lithography is trying to eliminate the water-dampening system on offset presses and creation of a truly "dry offset" process. L.T.F. has stimulated some hope in the development of a continuous tone offset plate similar to those used in the collotype—or photogelatin process. The use of new systems for ink-image attraction and ink-nonimage repulsion characteristics of surface plates is a definite possibility.

Letterpress is on the threshold of a major improvement through the use of thin-relief wrap-around plates for rotary presses. A number of machines for using this type of plate are being delivered this month. Much work remains to be done, however, on improvement of photographic and plate-making techniques in order that all types of subject matter may be faithfully reproduced.

Gravure is in need of a major revision of plate and cylinder making techniques to speed processing and reduce costs. Press speeds, drying methods, and web handling techniques have advanced rapidly.

Flexographic printers need a cheap direct plate. Possibly such a plate could be developed from a flexible photosensitive resinous material.

Silk-Screen printing has benefitted from a fairly recent series of coordinated improvements, but long-life screens, faster driers, and faster printers are needed.

Analysis and comparison of the common virtues of these various methods of printing point toward some possible combinations and consolidations. These include another attempt at the combination of a thin relief image plate (letterpress) and an offset blanket transfer. Another possibility is the combination of gravure with an offset rubber transfer blanket. Low priced gravure cylinders and special letterpress inks might eliminate the need for flexography as a separate process.

General need of all processes include a number of common goals. These are:

First. Simplified high-speed web presses with highly accurate tension and register controls and means to utilize removable cylinders for both letterpress and offset to allow a variable print length. In conjunction with these presses would be a series of finishing and binding stations which would be capable of interchangeable or consecutive handling of the printed web.

Second. Lower temperature high-speed drying methods for all processes. I think that everyone is looking forward to the day when the letterpress and offset printing processes will have a system of paper and ink which will allow accelerated drying through interaction of ink and paper upon contact in the press. This might involve substantial improvement in currently available heat and vapo-set inks—or it might come from actual drying reactions set up by substances in the paper and ink.

Third. Development of a new sheet to print on. This would involve an idealized material with some or all of the following properties:

1. No grain or directional properties.
2. Mechanical stability under a reasonable variation in temperature and humidity. A completely inert sheet would be ideal.

3. Uniform standardized surfaces with regard to properties of absorption, smoothness, color and brightness, and pick resistance or bonding strength if coated. This might enable the printer to specify his sheet on the basis of a series of numbers indicating the type of sheet desired.
4. Lint and dust free.
5. Lightweight. Uniform weight and caliper.
6. Controlled variable strength characteristics.

I'm sure that those of you in the paper manufacturing business can think of hundreds of reason why the above requirements cannot be met on a sheet of paper—but the material I suggest may not be paper as we now know it. It may be made from material not presently available or economical, on equipment yet to be developed—with completely new methods.

Fourth. Simplified photochemical and photomechanical systems. Developments in this field could help greatly to reduce the time and number of steps between copy and plate or cylinder exposure. The ideal immediate goal would be a single film step between copy and plate exposure. The ultimate possibility might be a photographic means for going directly from copy to plate. Process color work needs the development of a universally adaptable, simplified color correction and separation machine for use with any process or platemaking system. This might involve use of a recalibrating procedure which would enable the machine operator to reset the machine to correct and separate for a given platemaking and printing process by inserting a standard image, printed from plates made from a standard set of negatives. The recalibration would compare this print to a machine standard and reset the machine to compensate for the difference.

In the far distant future we might find that all of the temporal problems which we face now will have been solved by the development of a universal printing process which would probably be able to replace most of the methods now in use—and do most of the printing as we now know it. Such a process might involve a surface treatment or coating which would be energy sensitive and capable of reproducing the full gamut of color. This surface sensitizing or coating could be applied to any substrate. The printing operation would be primarily applicable to thin flexible materials up to 20 or 30 thousandths thick. The image reproduction means would be handled by a web-fed rotary printing machine, with the image formed by exposure of the web in intimate contact with a rotating cylinder, through which the energy would pass and form the image. The shape, size, darkness or lightness, and color of the image would be controlled by a tough thin film as a negative or positive of the image—the film being wrapped around the exposure cylinder.

Subsequent in-line stations would complete whatever binding operations might be involved and the delivered product would be ready for the customer.

At this point I'm sure that all of you are considering the possibility of sending me over to the Kalamazoo State Hospital for a mental examination. At the least you have me tabbed as an optimistic dreamer.

The point which I hope to make is that any future progress in this industry is dependent upon a coordinated effort by raw materials producers, machinery manufacturers, reproduction material processors, and printers—if true progress in basic ideas is to be made. Too many of us look at research as machinery gadgeteering and material formulation adjustment. True research is more likely to be an unfettered state of mind which is able to look beyond specific problems and into completely new areas of basic study to find new principles which may possibly be applied to use in industry for ultimate advancement.

I believe that it is important that those of you in the Kalamazoo area, which has such a wide variety of interests in the graphic arts, take an active interest in the broad program for study as outlined by Dr. Rogers and vigorously promote and help initiate it. There is some precedent for this action in the early days of what is now the Time, Inc., Springdale Laboratories. This facility was born here in Kalamazoo as the old Michigan Graphic Arts Lab and is now headed by Paul Thoma, an ex-Kalamazoo resident. This group is constantly exploring all phases of the graphic arts with considerable success.

Presented at the meeting of the Kalamazoo Valley Section of TAPPI, held in Galesburg, Mich., March 17, 1960.

Design and Research in Packaging

Larry Ruhmann

The rise of packaging from functional to merchandising uses is common knowledge. While at first the package had to meet protection and shipping needs, it later developed into a powerful tool to accelerate distribution and ultimately became an instrument for selling. With this came new possibilities but also new challenges. The package is no longer material only, it is a composite of materials and ideas, the former measurable, the latter seemingly intangible, all inextricably meshed in one. Its contribution cannot be solely defined as a part of production cost but as an investment in total marketing success. Businessmen must not ask what they can afford for packaging, but what packaging job is necessary to profitably market a product.

Now there is hardly any element in the package that represents its merchandising equity more than visual design. Through it brands and products are identified, quality associations are stimulated and products are set off from competition. In distribution, inventory controls, warehousing efficiencies, shelf replacement, etc., are accomplished through design. In short, labor is saved and product movement is sped up. While raw materials, technical research facilities, and production machinery for competitive products are often conspicuous by similarity, it is through packaging and design that images of products and services are created, that favorable or unfavorable communication is related to the public. The question that plagues every manager is how to obtain designs that merchandise products, how to soundly allocate funds for visual design and how to measure the sales effectiveness and merchandising impact of a design. In the past, decisions on design were mostly based on personal opinions and prejudicial taste judgments. As design developed into a decisive business factor, substantially adding to failure or success, it is evident that criteria for objective evaluation must be found, that methods of research must be elaborated and that the success of design must be marginally predictable.

Research in the area of taste is a highly controversial issue. If it is emphasized however that through research, design decisions are not made but rather facilitated, if it is maintained that while margins of error are reduced, intuition and creativity are not eliminated, then a basis of departure may be given.

Thus, one can theorize that design consists of elements such as color, typography, shapes, illustrations, texture, trademarks. If a design is to be successful, individual elements must work by themselves, must fulfill certain specific and general requirements and must work in relation to each other. In other words, elements of design have criteria which are successfully met by good designs. Color is effective because it is used economically, because it is appropriate for the product, because it helps identify, because it contributes to emphasis and de-emphasis of other design elements. Logotypes accomplish their purpose because they are unique and original, represent a personalized message, because they have visual clarity, adaptability, and again connect in some manner with the product. Illustrations may not only identify, but also contribute ancillary merchandising benefits such as appetite appeal. Design shapes add to visit size, help mass

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display effects of packaging units, create quality feelings, and impart again an element of uniqueness upon the design.

This type of analytical reasoning is admittedly theoretical and requires special qualifications in every individual design case. Often it may not suffice to render reliable criteria for evaluation and decision. If normal research is to be applied, two major areas of inquiry have to be considered. One area involves the testing of the design to determine its perceptual or recognition characteristics. The other area employs consumer interview techniques to investigate attitudes toward the product and its packaging. The former is concerned with mechanical factors of recognition as they apply to various conditions of viewing; the latter determines acceptance factors either by statistical approaches emphasizing sample selection or by attitudinal approaches, emphasizing types of question and determining attitudes, impressions and emotions toward products.

Some instruments used in perceptual investigations are as follows:

The Relative Visibility Meter determines the visibility of designs and design components under varied lighting conditions, and provides data on brand and product name legibility, recognition factors of colors, trademark symbols, and illustrations.

The Anglemeter discloses how well designs can project their messages from different angles of approach.

The Ocular Camera records consumer eye patterns stimulated by the designs, thus indicating the designs' eye attraction value and visual impact.

The Flashmeter, a projection device, is used to expose test objects for limited viewing periods before groups of respondents, thus disclosing the recognition-recall value of the testing items.

In addition to perceptual and consumer research techniques, photographic survey techniques may be effectively used to study package design performance in stores and at the point of sale, in warehouses or in homes. Increasingly, it is believed that an effective design identifies well in its retail outlet and entices the consumer to make a purchase. Secondly, however, the package will have to perform at home by virtue of its compatibility with home decors and color themes, shelf sizes in the larder or in refrigeration equipment or because of its de-emphasis of loud advertising slogans.

Advertising analyses may be performed to determine to what extent existing designs or newly proposed designs may serve as effective adjuncts to an advertising campaign or a general promotional theme, and Buyers Surveys may often furnish valuable clues leading to improved design strategy.

In many respects surface design research is still in a state infancy but it will greatly gain in importance as visual communication exercises more and more influence in business. The designer, formerly antagonistic to design research because he felt it might stifle his creativity, will more and more appreciate that information requirements for design development have become utterly complex. If he uses design research as a tool, he might well spend more time at the board where he prefers to apply his creativity.

Presented at the meeting of the Kalamazoo Valley Section of TAPPI, held in Galesburg, Mich., March 17, 1960.

The Role of Hemicelluloses in Pulp Behavior

E. E. Dickey

The predominant substance in the cell walls of hardwoods, softwoods, and other vegetable fibers is cellulose, and irrespective of the source, cellulose is cellulose in chemical and physical properties (*1*). Cellulose ranks first in abundance among nature's organic substances, and first in simplicity as a polysaccharide. No carbon compound has received more study than has cellulose. Yet, it still guards jealously secrets of real value for the pulp and paper industry. How exactly is it formed? Are there really "weak links" in cellulose and what is their nature?

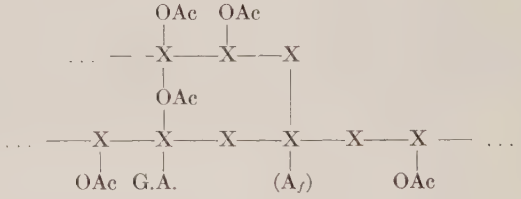
Intimately associated with cellulose in the fiber wall are the interstitial polysaccharides called hemicelluloses. Together with lignin and cellulose, these polymers exist as an interpenetrating system to form the most useful and amazing plastic known to science. This is wood, the gross features of which are shown in Table I. This is based in part on the paper by Hamilton and Thompson (*1*).

Table I. Composition of Carbohydrates of Wood

	Broadleaf, %	*Conifer*, %
Cellulose	40–45	40–45
Hemicelluloses	20–30 (mainly sol. before delignification)	15–20 (mainly insol. before delignification)
4-*O*-Me-glucuronoxylan	Very small	Small
4-*O*-Me-glucuronoarabinoxylan	Trace (tr.)	Medium
Glucomannan	Very small	Large
Galactoglucomannan	Tr., nil	Very small
Arabogalactans	Tr., nil	Tr. to med.
Other galactose polymers	Tr.	Tr., nil
Pectic substances	Very small	Very small
Starch	Tr., nil	Tr., nil

A large and rapidly growing body of knowledge exists about the chemical nature of the carbohydrates of wood. Our knowledge of the main hemicelluloses of wood may be summarized as follows:

Glucuronoxylans



where

X = D-xylose.
G.A. = 4-*O*-Me-D-glucuronic acid.
Ac = acetyl.
D.P. = 150–200.
A_f = L-arabinose.

The hydrolysis of this polysaccharide yields the expected D-xylose, some 4-O-Me-D-glucuronic acid, and significant amounts of an acid-resistant aldobiouronic acid. This acid was first obtained by O'Dwyer (*2*) and its structure was proved by Jones and Wise (*3*). In 1957, a crystalline triouronic acid was obtained by Hamilton and Thompson (*4*) and represents, it is believed, a unique portion of the glucuronoxylan structure. Many other workers have also contributed to the current status of knowledge about these polysaccharides.

Another type of polysaccharide which has more recently yielded to structural studies is the glucomannan.

Glucomannans

All β 1 → 4 D.P. <300

... — M - G - G - M - M - G - M - G - M - M — ...

where

G = D-glucose.
M = D-mannose.

The presence of mannan in wood goes back at least to

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the work of Bertrand (*5*) at the turn of the century or even farther to the work of Wheeler and Tollens in 1889 (*6*). But the isolation and characterization of specific polysaccharides from wood composed of glucose and mannose units has been a relatively recent development (*1*, *7*).

Just how the hemicelluloses are anchored in the cell wall so as to maintain their insolubility is still a controversial question (*8*). Certainly the accessibility of the hemicelluloses to alkali is much greater for the wood of broadleaf trees than for wood of coniferous trees (*9*). After delignification, however, the hemicelluloses from both types of wood are generally accessible to alkali and, to some extent, to water and certain other solvents (*10*). Possibly a lignin carbohydrate complex exists in the wood. Hypothetically, when the bonds of the complex are broken in delignification, the hemicelluloses are then accessible to alkali.

Another phenomenon which may illustrate a unique feature of the hemicelluloses in the wood fiber wall is the "skin substance" (*11*), a term no longer recommended in the original sense (*12*). When a spruce sulfite pulp fiber is treated with cuprammonium hydroxide it swells and balloons and eventually most of the cell wall dissolves. However, the outer portion of the fiber is rolled into a series of sleevelike constrictions that are relatively insoluble. This material contains a polysaccharide-copper complex which ultimately yields mainly D-mannose and lesser amounts of D-glucose under hydrolysis (*13*). This polysaccharide not only has a unique relationship to the outer wall of the fiber but also on its hydration behavior (*11*). Rollinson and Wise (*13*) further stated that irrespective of whether or not the portion which forms an insoluble copper complex is resident on the surface of the fibers, its presence or absence is admittedly of importance to paper pulp and dissolving pulp properties.

The influences and relationships between the hemicelluloses and pulp characteristics may be roughly divided into (1) effect on hydration in the beater, (2) influence on bonding and strength properties, and (3) effect on color and color stability.

The influence of hemicelluloses on the strength properties of papers made from wood pulp was first cited by Schwalbe in 1927, and has been explored by a number of workers over the past 30 years (*14–18*).

In the past most of the work was concerned with the relationship between the amount of hemicelluloses retained in the pulps, rate of hydration in the beater, and strength properties of the pulps.

A few studies have been reported in which isolated hemicelluloses have been examined as beater adhesives. Jones and Rieth (*15*) showed that an increase in strength resulted when xylan and a mannan isolated from a spruce sulfite pulp were employed as beater adhesives—the mannan was more effective than the xylan. Obermanns (*16*) isolated a xylan from a soda pulp and added this to rag, sulfite, and alpha pulps in the beater and found that the rate of beating and strength properties were improved. March (*17*) added dry aspen hemicelluloses to aspen pulps in the beater, and found that the addition of small amounts improved the bursting strength but that the addition of large amounts did not produce strength improvement—and tended to impair the strength.

From these and other studies it is generally recognized that in the absence of hemicelluloses or of some suitable beater additives, and without excessive beating, a strong sheet of paper cannot be made. Pure cellulose does not hydrate readily or practically.

On the other hand, uses which require purified celluloses may be considerably harmed by the presence of hemicelluloses. For example, in the manufacture of cellulose acetate relatively small amounts of mannan or xylan may give rise to "hazy" acetate solutions and to clogged filter presses (*19*).

Thus far, little attention has been given to the significance of differences in chemical constitution and in chain length of the hemicelluloses from various wood species. Cottrall (*18*) has emphasized the need for extending the studies as follows: ". . . further investigations to determine the changes, not only in the quantities, but also in the nature and compositions of the different hemicelluloses remaining in the pulp after the wood has been treated with the various reagents, especially the liquors normally used for pulping, would be very revealing, particularly if these results were related to the papermaking properties of the pulps . . ."

In the important field of fiber bonding, Forman (*20*) has stated that one of the greatest unknowns seems to lie in the realm of hemicelluloses, yet information about them appears to be essential to solution of the fiber bonding question.

Subsequent work at The Institute of Paper Chemistry (*21*) in which aqueous solutions of representative and degraded hemicellulose fractions from aspen, spruce, and Douglas-fir have been examined as beater adhesives, has shown that, in addition to concentration, the D.P. and the chemical composition of the hemicelluloses are major factors influencing strength properties. A marked reduction in adhesive strength was observed when the degree of polymerization of a representative hemicellulose fraction was seriously reduced by hydrolytic scissioning. There appears to be a critical minimum of D.P. below which no strength improvement is realized. Further, the hemicellulose from the softwoods were found to be superior in adhesive properties to their hardwood counterparts of comparable D.P. This superiority has been tentatively attributed to the higher hexose content (chiefly mannan) of the former (*15*, *21*). Little precise fundamental information, relating to the molecular properties of representative hemicellulose fractions from the various pulpwood species, is available.

Studies of the hemicelluloses remaining in the pulps have shown some of the possible relationships between the composition of the pulps and their properties. In general, those pulps which contain higher concentrations of hemicelluloses, up to a certain maximum, have been found to beat faster, to develop greater strength than the corresponding pulps containing lower concentrations.

In kraft pulping of pine, most of the galactose and arabinose units, 70% of the mannans, 50 to 70% of the original xylans, and about 15% of the glucose units in the original wood enter the black liquor initially in the form of (modified) hemicelluloses (*22*). Early in the cook, certain of these fragmented hemicelluloses can be recovered, but they are later degraded and converted into sodium salts of various saccharinic acids (*23*). Saarnio, Wathén, and Gustafsson (*24*) prepared sulfite and kraft pulps from spruce, pine, birch, and aspen, and analyzed them for pentosan, uronic acids, and component sugars (chromatographically). Sulfate pulps of spruce and pine were free of uronic acids, but these acids were present in all sulfite pulps and in the kraft pulps from birch and aspen. Yllner and Enström (*25*) have more recently demonstrated that the hemicelluloses are in fact wanderers during pulping—especially alkaline pulping—and come to reside in locations in the fiber wall where they are much less accessible to alkali or acid hydrolysis. This phenomenon is largely unexplored at present, but probably holds the key to a much improved understanding of pulp properties.

In recent years the physical chemists have indeed been coming into the field. The nature of sorption has been explored by several workers. Most (*26*) was the first one to use carbon-14 tagged hemicelluloses to measure the rate and degree of sorption on cellulosic fibers. Russo and Thode (*27*) used a radioisotope labeled locust bean gum and developed the nature of sorption in more detail. In these and in other studies, sorption was observed to be irreversible, no equilibrium was involved, the energy of activation was found to be about 4500 cal., and the rate of sorption was diffusion-controlled.

In the realm of color stability most of the chemistry is discussed in terms of chemistry of colorless substances.

There is almost no work directly on the decolorization of colored substances. Such work as the recent studies of Theander (*28*) holds some promise for a better understanding of bleaching. The 3-keto groups plus alkali yield a yellow substance.

There is much to be learned by the chemical separation or dissection of fiber components. Surely the extraction of a pulp with strong caustic or strong acid must obliterate whatever relationships may have existed in the original fiber. How can studies which involve such treatment be expected to reveal anything about those delicate relationships? Thus, more may be discovered by the application of ingenious techniques to the intact fiber under realistic conditions. Physicochemical studies should be highly productive in probing the mysteries of the papermaking fiber.

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Presented at the meeting of the Kalamazoo Valley Section of TAPPI, held in Galesburg, Mich., April 21, 1960.

Eleventh

Testing Conference

Pantlind Hotel

Grand Rapids, Mich.

Sept. 27–29, 1960

Maine-New Hampshire

Head table at banquet, Friday night (left to right): Seated —Chairman Andrew Chase of the Univ. of Maine; James W. Field of TAPPI staff; George Olmstead, Jr., President of S. D. Warren Co., banquet speaker; Philip E. Nethercut, Secretary-Treasurer of TAPPI; Chairman-elect Edward N. Poor of Hudson Pulp and Paper Co. Standing—Robert E. Perry, Scott Paper Co.; Donald Bail, Great Northern Paper Co.; Secretary-Treasurer Harold E. Pratt, Pejepscot Paper Co.

Technical Program Chairman Edward N. Poor of Hudson Pulp & Paper Co. with J. B. Scott (left) of E. D. Jones Co. and R. F. Barber (right) of the Foxboro Co. who presented papers at the Friday technical session

Retiring Chairman Andrew Chase of the University of Maine hands over the gavel to newly elected Chairman Edward N. Poor of Hudson Pulp and Paper Co. while Secretary-Treasurer Harold Pratt of Pejepscot Paper Co. watches

Philp E. Nethercut (right) Executive Secretary of TAPPI presents certificate to outgoing Section Chairman Andrew Chase of the Univ. of Maine as J. W. Field (left) of TAPPI looks on

Panel members at Saturday morning panel discussion (left to right): R. F. Barber, Foxboro Co.; J. B. Scott, E. D. Jones Co.; E. F. Thode, Univ. of Maine; John Lewis, Pulp & Paper Research Center, Inc., moderator

The Response of Chemically Pulped Wood Fiber to Mechanical Treatment

Edward F. Thode

Before entering upon a discussion of how chemical pulp responds to mechanical treatment it is worth while briefly to examine why such treatment is customarily practiced. If we view the stock preparation system and the fourdrinier or cylinder machine as a single system we should conclude that the single basic objective of this system is that of obtaining a well-formed sheet with specific basis weight and caliper requirements, plus the certain requirements of physical and optical properties which may be subordinate, or dependent upon, formation, basis weight, and caliper. The refining part of our system, therefore, must do its part in *preparing* the stock so that the machine can *finish* the job. While the old-time papermakers assert that paper is made in the beater, this is not entirely true, nor was it ever so. There is strong evidence to indicate that a skilled papermaker can overcome many deficiencies in stock preparation by the mode of operation of his machine.

With these broad objectives in mind, we should look at the response of specific pulpwood characteristics to the refining operation, not from the point of view of a one-to-one correlation of chemical fiber properties to properties of the finished paper, but from the point of view of how this property will blend in with the many other variables of the system to produce the desired end product. I cannot overemphasize the point that undue attention upon relations between isolated properties is usually highly unproductive and, quite often, highly misleading.

The variables in a pulp which affect the response of the stock to mechanical treatment may be classed under the two broad categories of pulpwood variables and pulping and bleaching variables. Under pulpwood variables we have such properties as fiber length, fiber diameter and lumen diameter, fibrillar angle, inherent fiber strength, lignin content, and the content, analysis, and distribution of the hemicelluloses. Under pulping and bleaching variables we may list mechanical damage in chippers, feeders, blow tanks, and so on, the completeness of delignification, the removal, conversion, and redistribution of hemicelluloses and the degradation of the alpha-cellulose portion in both the pulping and bleaching operation. The various physical properties in the finished sheet will depend greatly upon the above variables and, of course, upon the response of the above properties to the beating and refining action. For example, an extremely long-fibered material, which would be expected to give both good tear and tensile, may so knot up and generally behave badly in the beating equipment that quite poor formation is obtained on the paper machine. The resulting sheet will, therefore, not begin to approach the strength and, especially, the uniformity of optical properties which might be expected from the general relation of fiber length to strength properties.

PULPWOOD VARIABLES

I will not bore you with a textbook discussion of the six pulpwood properties listed above, but rather will comment on two of these which have become of particular interest recently.

There has been much discussion of the importance of the *inherent strength* of *fibers* in the past two or three years since J. A. Van den Akker and his associates at The Institute of Paper Chemistry demonstrated that a large proportion of the fibers in a sheet of paper actually do rupture in the course of a tensile break. Previous to that time it had been a rather widely held belief that bonding of the fibers one to another was of almost overwhelming importance and that few fibers actually broke, in, say, a tensile failure. Bonding is still to be considered an extraordinarily important factor, but now it appears that the strength of the individual fibers is also very much to be considered. Until very recently, we had no good means of estimating the ultimate realizable strength of wood fibers. Now it appears, from as yet unpublished work, that such estimates can be made with reasonable precision on the order of, say, $\pm 20\%$. A very interesting point observed in this work is that the maximum realizable fiber strength of chemically pulped fibers is quite a bit higher than the strength of these fibers as they exist in the native wood. I mention this point because in our pulping and bleaching procedures we have had no yardstick to tell us how much damage to fiber strength was actually occurring, compared to the best obtainable of a given species. The indications of current research are that this situation may shortly be changed so that, if in one case we find a commercial process is giving us 90% of realizable tensile strength no time need be wasted on development, but if, on the other hand, only 40% of ultimately realizable strength is obtained a strong improvement program in that property may be called for.

The matter of *hemicellulose content and distribution* is now coming in for extensive research work in various organizations throughout the world. Improved methods of physical testing in just the past few years have shown that very striking physical differences between pulps can be attributed mainly to a

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difference in the bonding strength per unit bonded area of the fibers in the sheets of paper. While there may be some strictly morphological factors involved here, as will be discussed in just a few moments, the inference is quite plain that the major difference is in the chemical constitution of the fibers and particularly in the modification and redistribution of the hemicelluloses originally present in the fiber.

PULPING AND BLEACHING VARIABLES

The above comments ease us into our discussion of pulping and bleaching variables: First, *mechanical damage*. This is something that practical men in the industry have studied for quite a long time, but with the advent of continuous pulping requires very searching re-evaluation. There is no doubt, from the accumulated evidence, that mechanical working of the chips at the right time near the beginning of a cook will greatly improve penetration and improve the fiber obtained from the cook. Mechanical damage at the wrong time in feeders or in continuous digesters can greatly reduce yield and adversely affect physical properties. This, unfortunately, is often the function of the specific system involved; it is certainly an item that should be looked at if inexplicably poor pulp properties are encountered.

Completeness of delignification is a rather obvious factor in mechanical response to refining which also needs re-evaluation in view of newer pulping techniques which alter the lignin-hemicellulose ratio in the pulp from that which has been conventionally encountered in regular sulfite or regular kraft pulps. The redistribution of hemicelluloses during pulping and bleaching was commented upon briefly above. There is absolutely no doubt that if hemicelluloses can be retained with the proper molecular weight and composition relationship a very easy beating pulp is obtained—one that will ordinarily give an excellent balance of physical properties. The results obtained in so-called Sivola-type cooking, which is two-stage bisulfite, neutral sulfite pulping, are quite impressive from this point of view. Recently, in strictly alkaline pulping, Hartler has shown that the addition of sodium borohydride to a kraft cook increases the yield from 46.7 to 51.2%. The pulp contained up to 80% of the glucomannan originally present in the wood as compared to about 30% for an ordinary sulfate pulp. When compared to a normal sulfate pulp this higher yield material was brighter and was more readily beaten than regular kraft pulp but showed typical kraft strength properties. While sodium borohydride pulping is economically unfeasible at the moment, this is a strong indication of the direction that chemical pulping must take to produce the improved products required for the future.

Finally, before leaving the matter of pulping and bleaching variables, we would comment that *degradation of the alpha-cellulose* portion during pulping and bleaching is the worst offender in reducing originally high fiber strength. Now that we realize the very great importance of fiber strength, it has become almost commonplace in the industry to pay more and more attention to exerting great care in commercial operations to avoid unnecessary degradation.

TECHNIQUES OF MEASUREMENT

If we are to determine, for papermaking purposes, the response of chemical wood pulps to the refining operation there must be good methods of measuring this response. Measuring it only in terms of the derived properties of the finished sheet of paper are quite unsatisfactory, primarily because of the great blend of factors which enter into any given finished sheet property.

Fiber Length

In beginning a discussion of wet pulp relationships we must not neglect the importance of fibers, fibrils, and fines in producing strength and optical properties in the finished sheet. As you well know, W. Boyd Campbell, some years ago, elucidated the generally accepted surface tension theory of sheet formation. Dr. Campbell pointed out that as a wet web of paper dries, the greatest single compacting force involved in drawing the fibers together is that of the surface tension of the various menisci of liquid which retreat in the interfiber pores as drying proceeds. The smaller these pores are, the greater the effect of this surface tension action. Therefore, the presence of fibrils and of fines contributes greatly to the forces which naturally compact a sheet. In determining the response of a pulp to refining therefore, one must not neglect either very precise or more crude alternatives for determining fiber length, fiber-length distribution, and fines content. Therefore, various of the manual and semi-automatic microscopic methods for fiber-length measurements now in use can be very helpful. Classifier analysis is valuable and, for certain routine control purposes, a great deal of information can be obtained from the quite simple grid test for fiber-length index developed by Ray de Montigny. We have used this latter test with a great deal of success in a number of studies of control correlation.

Surface Area

Also of great importance to sheet properties, both in determining bonding potential and in fixing the ultimate strength and optical properties of a sheet are surface areas exhibited by the pulp. Actually, there are two different surface areas with which we must be concerned. One is the hydrodynamic external surface, which is that found in suspension and which largely determines the drainage of the stock on the machine. The other is the dry surface area of the fibers in the finished sheet. This area is much smaller than the first and may be subdivided into that part which is joined together in fiber-to-fiber bonds, known as the *bonded* area, and that which is *not* so joined, the so-called *unbonded* area. Optical properties, such as opacity, depend greatly on the absolute amount of this unbonded area.

The classical freeness test is the simplest estimate of *hydrodynamic* surface area. However, it is not at all a good test for surface in comparing pulps of different species and of different fiber characteristics. It is not at all good for either lightly beaten pulps or very heavily beaten pulps but it is useful in the intermediate range, especially if a fairly consistent stock is being processed. Nevertheless, one can be quite far off, especially on drainage properties, if one does not make a more precise determination than this freeness test. The filtration resistance test developed by W. L. Ingmanson or some of the related pad permeability methods give much more reliable indications both of behavior on the paper machine from a drainage standpoint and of the actual amount of hydrodynamic surface present in a beaten pulp. Such determinations have been found to be quite useful in machine design, because if made with sufficient precision, they may be correlated directly to the amount of drainage to be encountered on a table roll section and thus can be used to predict the wire length on the machine which is optimum for the type of product to be obtained.

The most convenient method of estimating the *unbonded* surface area in a finished sheet is from determination of specific scattering coefficient of monochromatic light using a device such as the General Electric recording spectrophotometer. The relation of the optically unbonded area so determined to the unbonded area determined by gas adsorption should be the same for all types of pulp. However, recent experience in a number of studies indicates that this is not always so. Further, a base line for the relation of the light scattering of a particular pulp to its gas adsorption surface area is not presently available from theoretical consideration. Therefore, determinations of bonded and unbonded area which are critical to certain optical properties and strength properties need to be performed by gas adsorption.

I might conclude this section on surface-area determination by commenting that there are several methods in which some

of us present have been interested that are now only of historical interest. The chairman of your section and myself spent some years studying dye adsorption on fibers as a guide to beating. While there was a certain demonstrable value to such an approach, the combination of filtration resistance, scattering coefficient, and gas adsorption methods has turned out to be of far greater fundamental import and far greater value in the interpretation of stock refining behavior.

Swollen Specific Volume

Another wet pulp property of extreme importance is that of *swollen specific volume*. The Campbell effect alluded to above will operate most usefully on fibers if they are pliable or plastic. Generally, therefore, the greater the swelling of the fibers, either from chemical treatments or, more usually, from the mechanical action of the beaters, the greater the bonding that will be obtained in the finished sheet. This swelling of the fiber is truly what is referred to when the papermaker uses the term "hydration." However, this swelling is not adequately measured by the freeness test, although, there is necessarily a certain correlation between freeness and hydration. The filtration resistance technique and related permeability technique can determine swollen specific volume as well as external specific surface area. This is done with the aid of a separate measurement of the compressibility of a pad of fiber; such determinations are somewhat tedious, but if done rigorously are extremely valuable.

Reasonably accurate but theoretically somewhat unsound estimates of fiber swelling may be obtained by several of the centrifugal methods of water extraction. Any of these methods, the most recent of which are the water-retention value technique of George Jayme and the centrifugal water-retention test developed at the Institute, depend on applying a high centrifugal force to remove as much as possible of the free water between the fibers while retaining the water of swelling within the fibers. This, of course, really cannot work because the deformation of the fibers under the high centrifugal field squeezes some water out that is really water of swelling, whereas the surface tension forces in the voids between the fibers prevent expression of all of the interfiber water. However, the centrifuge test is reasonably quick, reasonably convenient, and requires little in the way of expensive equipment or highly trained technicians. In pulp evaluation studies both here and abroad in the past five years, it has been demonstrated to be extremely useful as an *estimate* of hydration and to correlate extremely well with paper properties. Our experience with this test is that it is more sensitive to changes in basic fiber characteristics and to changes in refining characteristics than is either the freeness test or a measure of fiber length and fines.

RELATION OF TESTS TO SHEET PROPERTIES

In evaluating the relation of wet pulp tests to finished sheet properties we must bear in mind that these properties are necessarily a compromise and involve at least two critical balances; one, the balance among the various properties of strength normally considered to exist *in the plane* of the sheet, such as tensile strength, burst, and tear and the properties in the *direction normal* to the plane of the sheet, such as pick resistance, fold, and various evaluations of printability. The other balance involves various of these properties and optical properties such as opacity. Tensile strength, for example, is primarily affected by the individual fiber strength of the beaten fibers, fiber length, some factor involving bonding (which includes both bonded area and strength of bonds within the bonded area) and then an important formation or orientation factor, as previously discussed. Fines, for example, may contribute relatively little to normal tensile strength but may have a very great effect on the tensile strength of a sheet in the direction perpendicular to the plane of the sheet, and therefore may make a very great difference in the pick resistance of a base sheet. As previously indicated, they will also make a very great difference in some properties, such as the fold.

In determining the balance among these properties, the external specific surface (that is, the wet specific surface area) may play a very important role. Of itself, the hydrodynamic specific surface does not appear to be particularly important in any of these sheet properties, but the relative amount of surface found in fines and found in the "whole fibers" is particularly important. Likewise the balance of strength properties and opacity may be quite disconcerting. Development of a high amount of bonded area will give a sheet with good pick resistance and with high tensile strength, will probably yield inferior tear, and will probably yield inferior opacity. A change in cooking or bleaching conditions may produce a pulp with greater bonding strength per unit bonded area. Such change will mean that less beating is required to obtain a given level of tensile. This lesser amount of beating may produce a lesser amount of ultimate bonded area in a sheet and so will give improved opacity. This is but an example of why it is necessary to go back and look at the various basic properties when deciding what balance to achieve between refining and the chemical properties of a pulp that determine its response to refining.

RELATION OF TESTS TO BEATER AND REFINER OPERATIONS

Our closing topic, therefore, includes some very brief comments on the relation of both wet pulp tests and paper sheet tests to beater and refiner operations. I would first reiterate our opening remark that we must look at this from the broad view of the entire system. Several studies made recently lead me to believe that the specific action of any particular type of beating engine is usually not so critical that it cannot be counterbalanced by appropriate changes, either in the pulp variables or in the paper machine variables. There are fairly strong indications that if you can achieve a certain balance of wet pulp tests, namely fiber length, distribution of surface area of fines and fibers in the proper proportion, and degree of swelling of the pulp, it really doesn't matter too much what type of equipment was used to obtain these properties. It is, of course, true that some types of equipment will develop one or another of these properties more rapidly and more efficiently in specific types of pulp. We are all familiar with the effect changes in alloy composition and bar width have on the performance of common bar-to-bar refiners as regards the hydration and cutting of a given type of pulp.

To us the interesting point is that it is often easier to change your pulp than it is to change your refiner, considering the very high investment in the refiner. In installing *new* equipment, one should attempt to "tailor-make" the equipment installation to the available run of fiber and the desired type of product. However, it is not necessary to throw out a serviceable piece of equipment when product requirements change. The other speakers on the program can do a better job than I on the characteristics of particular refiners. With no intention of stealing their thunder, I would like to point out that the application of a battery of pulp tests and of paper tests as part of a refiner evaluation study can be quite productive of broad interpretation of the possibilities of the refiner. I very strongly urge conducting statistically designed experiments in this realm.

By use of a battery of test methods and multiple-correlation techniques, one can quite rapidly isolate (1) the main effects on properties obtained from the action of the refiner, that is, if comparisons are being made of refiners, and (2) the importance of the contribution of the refiner, its power setting, etc., to the properties in the finished sheet. Quite often, as I have just indicated, such a study will show that there are many ways in which the desired product may be obtained.

In closing, may I offer an admonition—so many times we become involved with the details of, say, a refiner study, we forget that we have the broad objective of making paper.

Let us *not* forget that paper ultimately results from the skill of the artisan curiously turning nature's handiwork to man's use.

Presented at the meeting of the Maine-New Hampshire Section of TAPPI, held in Whitefield, N. H., June 17, 1960.

The Economics of Wet Lap Pulp Handling

M. C. White

At the Oxford Paper Co., as at most paper companies, pulp production does not balance exactly with paper production. Therefore, there must be some way of handling excess pulp so that it will be available, either for sale or future use.

Back in 1952, the Oxford was producing rolls on a pulp drier to take care of the surplus pulp production. The rolls weighed approximately 100 lb. each and it required a crew of eight men to produce and load the rolls—five men operated the drier—one man was a weigher and two men were necessary to load cars.

The pulp, loaded into cars, was either sold to other companies or put in storage for breakdown or stream pollution use. I believe all of you, who are in any way associated with the paper industry in this area, realize that stream pollution can be quite a problem. The pollution problem on the Androscoggin River is handled by a river master who works for the State. All test results, which are made by all three paper companies on the river, and by the State, are analyzed by the river master and he determines the total allowable production of pulp for each week during the summer. This is divided up among the three mills, based on their average production during the year. As a result, during the summer the Oxford Paper Co. cannot produce sufficient sulfite pulp to meet production requirement and therefore a great deal of pulp has to be placed in storage during the winter for use during the summer period at what we call the "Island Division." While this mill is physically only about a quarter of a mile away from the main mill, the circumstances are such that the material has to be transported either in freight car or by road truck.

When rolled pulp was sent to the Island Division for storage, it required from six to ten men for unloading, dependent upon the location and piling height. Two men loaded the pulp onto wagons from the cars—two to four men pushed the wagons from the cars to storage and two to four men piled the rolls in storage.

With the increased use of mechanized equipment for material handling, it was decided that we would have to shift from rolls to bales for our dry pulp. Consequently, a bale press was installed. This immediately resulted in a reduction of one man in the crew required to operate the drier and load the cars.

In the time since we initially started baling pulp, this crew has been reduced to five men and our cost for pulp loaded in a car has been reduced by approximately 36%. The cost for transportation, for the pulp being sent to the Island Division for storage, has also been reduced because we are able to load 50 tons of bale pulp in a car, compared to the 30 tons of roll pulp that we used to load.

Further economies are gained through bale pulp because it requires less storage space and allows much better inventory control.

However, the drier capacity was not sufficient to take care of both our hardwood kraft pulp and the sulfite pulp required for stream pollution purposes. As the hardwood kraft pulp was salable and there is a good market for it, the company did not want to cut back on their hardwood production. Also, it would have boosted the cost of the hardwood used in our own paper production because the kraft mill would not be operating at capacity. To take care of this requirement for pulp, it was necessary to produce hand laps on five wet machines, plus rolled pulp on two of our oldest paper machines, which were not being used. These old machines each had a capacity of 38% of that of the drier and, yet, the crew required to operate each machine was equal to that used on the drier. The result was that this was a very expensive method of producing pulp for the pollution period.

The hand lap machines were also very expensive. It required a crew of one man to tend the five machines, plus one man on each machine to fold the laps and place them on trucks and four men to load the laps into cars. Due to the moisture content of the pulp, the hand lap operation was the most expensive of the three methods.

Experiments and studies were made to find a more economical method of preparing pulp for stream pollution. It was decided that blanket lap production, while more expensive than drier operation, would be much cheaper than either the old paper machine roll production or the hand lap operation. It would require one man as a machine tender and one man to operate the two blanket lap machines. There would be no expensive costs involved in loading because the truck operator who loaded the pulp from the drier would have sufficient time to load the blanket laps.

The blanket lap machine produced a web of stock 8 ft. wide making two 4-ft. wide strips. The blanket attachment piles the pulp onto "take it or leave it" pallets which were designed to fit our specifications. The pallets sit on four wheel dollies so that as the loads are completed, they are pushed aside and an empty dolly with pallet is put in position. The truck can then remove the pallet from the dollies while the next load is being produced.

The pallet loads were loaded into frieght cars for transfer to the Island Division storage area. At the Island Division, the pulp was stripped from the pallets and placed into storage. As you can imagine, the storage problem was very difficult because the stacks of pulp would lean in any direction. More than one day was spent picking up piles of pulp that had fallen over. Housekeeping was a tremendous problem but luckily for us the company brass seldom visited these areas and I guess our safety and housekeeping inspector threw in the sponge and confined himself to safety and flagrant abuse of good housekeeping.

Transfer of pulp from storage back to the mill for use employed the same process. The pulp was removed from the storage piles and placed on pallets. The pallets were then loaded into cars for transfer. If the pulp was to go directly to the beater room, it was delivered on the pallets; however, if it was to go to temporary storage it was stripped from the pallets.

The natural question you would ask is: "Why bring the pulp down until you are ready to use it?" The answer is that the weeks allotment of sulfite pulp was all produced the first five days of the week and the make-up pulp was used on Saturday and Sunday. Limitations of men, equipment, and railroad track space made it impossible to handle the required tonnage in these two days. Also, we were attempting to hold Sunday time to a minimum.

The two major problems we ran into in handling pulp in this manner were space requirement and uneven loads. In order to rectify both of these, a press was installed in the wet machine room. The pallet loads of pulp were placed on this press as they were taken away from the wet machines and the pulp was pressed down, decreasing the volume of space required and making the top surface level so that the pulp could be stacked. The installation of the press was well worth the cost on the basis of stability alone. We did, however, make some monetary savings because the size of the pressed loads were such that we were able to load three pallets high in the transfer cars, rather than too high as we had previously done. We were also able to pile more tonnage in the same cubic area in our storage locations.

As the so-called "Island Division" was originally constructed as a paper mill, rather than a warehouse, there were

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many areas which required the use of an elevator, both in getting material in and out. By increasing the tonnage stored in the areas, which were on track level, we were able to cut the handling cost down.

This system continued in effect for a few years and then we ran into an additional problem. The "take it or leave it" pallets that were in use for handling pulp were becoming rather old and, due to the constant wetting and drying, the wood was splintery. These wood splinters stuck to the wet pulp and we began to have trouble with splinters in the stock. There were several obvious solutions—one was to purchase sufficient pallets so that the pulp could be stored on the pallets up until the time it was used. This would have meant the purchasing of approximately 11,000 pallets at a cost of between $45,000 to $55,000. Another solution was to buy 800 stainless steel or aluminum pallets of the "take it or leave it" design at a probable cost of $28,000 to $30,000. The best solution would, of course, be to eliminate the pallet altogether so that is what we did. We found that by placing the load of blanket lap pulp in the press and leaving the forks underneath the load, we not only compacted the pulp into a stabilized mass, but we also left openings for picking the pulp up at a later date.

In order to accomplish this, we designed a special pallet and had eight of them made up. These were made of wood with a top covering of metal with an opening 4 in. deep left on the top surface so that the forks of the truck could slide in under the load of pulp and lift it off. These pallets were placed on the dollies used at the wet machines. At first, we thought we would have to use metal plates on the floor of the railroad cars, but experience showed that a paper lining would serve the purpose at a much lower cost. In comparing our present cost of handling our stream pollution pulp with the original cost, we find that each change effected a small saving and that when they are all put together, we have a very substantial reduction in costs.

Presented at the meeting of the Maine-New Hampshire Section of TAPPI, held at Whiteface, N. H., June 17, 1960.

Finishing: Success or Failure

A. R. Perrin, Jr.

In a recent P.T.J. article the following summary statement was made: "We do have difference, true, but not so basically that every mill must resort to special designs and ways of doing things that require a custom treatment throughout and are found nowhere else except that mill."

This thought was in my mind when Don asked me to give some "thoughts on finishing" at this meeting. We are by no means extraordinary finishers at S.D.W., and I'm sure some of what I have to say is not new to you. But, perhaps you may pick up an idea here and there of value to your own operations.

We have had both failures and successes in our attempts to improve finishing efficiency. I would like to discuss both here.

Keep in mind that I am speaking of a mill making a complete line of plain, machine coated, and coated papers along with a sizable smattering of specialty items. We finish about 87% sheets-13% rolls. Of the sheet tonnage 70% is on skids, 25% in cartons, and 5% in wooden cases.

ROLL CERTIFICATION

The largest factor involved in the reduction of paper finishing costs is that of quality. The quality of the paper coming to your finishing department affects sheeting and inspection costs, waste, and to a lesser extent trimming and packing costs.

Fortunately we are blessed with a group of fine papermakers in our production department. To take advantage of this high level of quality, we have set up a program called "roll certifications." By this we mean that each machine operator —whether paper machine, supercalender, coater, embosser, rotary cutter etc.—passes judgment on each roll which he processes. This judgment or certification is recorded on the roll identification ticket and is used to inform the next operator as to the quality of that particular roll.

Such information is invaluable in the sheet finishing area. Good rolls may be cut together and given a brief inspection; bad rolls, possibly cut together, are given a more thorough inspection. Each of these inspections is based on the economics of the paper quality and end use involved. But the main lesson to be learned here is that inspection costs may be reduced. The one bad roll of five, properly identified, will be left out of that particular roll set, and cut single or with other similarly defective rolls.

Obviously, this is a long range program. All operating personnel must be trained to a reasonable understanding of the various end use qualities. Where substantial costs is fanning and/or sorting inspection personnel, space, and equipment are involved, perseverence in a certification program will pay dividends. Sometimes I become irritated with the temporary setbacks our program endures. But more than once it has been suggested that if I'm such a good papermaker I should be over there in the paper manufacturing department. I'm not such a papermaker. They know it and I know it. So we continue to progress toward a better system of quality communication.

In our operations where production depends on the ability to group cut a substantial number of orders, and to keep our inspection stations producing at a reasonable rate, paper quality is an important key to production. If this production experiences a significant drop, surge areas quickly fill up, costs go up in the areas affected, waste increases, and very shortly costs increase in areas dependent on the production of these inspection stations. In other words, poor paper quality can quickly make finishing a very inefficient operation no matter the basic efficiency of your particular finishing systems.

INSPECTION

One of our more successful ventures has been the use of hydraulic lift tables at our count and fan stations. The old method of fanning inspection has many good applications for grades where a few random defects and some nonrandom or stratified defects are common. We use two lift tables—one for the working load, and one for the finished load. The female inspector accomplishes the necessary amount of fanning on a quantity of paper on the working load. She then slides this paper onto the finished load in small lifts—the size of the lift depending on the sheet characteristics and the physical capabilities of the inspector. These lifts vary from 20 to 50 sheets. We have, then, in addition to our fanning inspection, an inspection of a full sheet every 20 to 50 sheets. Should the paper become defective to the point where fanning inspection is no longer safe, then it is a simple matter to single- or two-sheet sort until the particular defective area has run out.

Here is an example of an application of standard equipment which produces an application of standard equipment which produces an excellent result for us. The main advantages are these: (1) the inspection of each load is completed in the one operation, (2) piling is accomplished by the female inspectors, and (3) quality and efficiency of inspection are improved.

TRIMMING

In recent years there have been many systems developed to improve the efficiency of mill trimming operations. Southworth, Rice Barton, American, and others have come up with satisfactory methods. However, each of these has certain limitations which were important enough to cause us to look for even better systems. We have developed a method which we feel has the necessary efficiency and flexibility for our production.

The method consists of the following:

1. A hydraulic levelator which maintains the untrimmed load at the proper height for either pulling directly onto or turning over onto the loading table.

2. An overhead paddle-pusher which drives three to six press-loads of paper down the 280-in. loading table. This pusher is activated by a limit switch triggered by the trimmer press tailboard.

3. The piler or unloading table is a simple short-mast stacker set on tracks in the floor and driven by a rubber wheel. The forks of this stacker carry a re-enforced air flotation table top with an 8-in. lip on the unloading end.

With this equipment loads are pushed onto the side of the press with the tailboard all the way back. The trimmed load is then pushed onto the piler by the untrimmed load via the tailboard. The other piler is run over the skid and dropped 8 to 10 in. short of the skid platform end, the paper lift pushed off the air table, positioned on the skid, and the piler table is then raised slightly and driven out from under the pressload of paper. The piler returns and positions itself in a preload area ready to receive the next lift from the press.

Limit switches are used to control the table from preloading positions to prepiling positions. Another switch shuts off the table air when the piler is in motion.

Three men are used in this operation. All three are trimmer operators and rotate each hour from the trimming position to the loading-unloading positions. Our production on this press has increased 26.5% per man-hour and 27% overall. I should point out, however, that we feed our largest paper into this press and never trim more than a two-out-of-one sheet. We will shortly equip another press in this fashion and, then, with keener competition for the large sheets, the production figures quoted above will be reduced a bit. But, we feel that the efficiency and flexibility of this system is superior to anything we have seen thus far.

PACKAGING

Under the heading of packaging I would like to discuss two items—one, skid packing and, two, carton packing. We have had our failures in both of these areas. I will outline both the failures and what we hope to be successes in these packages.

Skids

Several years ago a great deal of effort went into the development and field trials of a skid wrapped only in corrugated board—no straps, no wooden cover. This was accomplished by using precut corrugated panels and cap or top piece which were placed around the skid and held by latex adhesive. This skid and corrugated cover or "kimona" as it was called, was then placed under a hydraulic pressure station. While under pressure the corrugated panels were nailed to the skid deck. This produced a skid with excellent protective wrapping, but unfortunately insufficient tension to hold the paper in place. Several methods of securing the corrugated board to the skid deck were tried unsuccessfully. This proved to be the major problem in the development of this package. Other minor difficulties were the opening of the skid and disposal of materials.

We learned something from these trials, however. It was this: that we do not like to funnel all our skids through one fixed station. The idea of a pressure packing station has been dropped. Our new system, now being built, is multiple tool strapping. Our tests indicate that in strapping a skid with one tool the first two to four straps are used to remove the air from the paper and to adjust the package—the last two to four straps actually tension the load. If an individual strapping tool is used for each strap—and these tools tensioned simultaneously, a more even distribution of tension obtains. Since all straps are actually used to tension the skid, fewer straps are required. The average number of straps per skid is now approximately seven—we plan to reduce this average to five, possibly four. We feel that this move is justified because only that number of straps useful in applying tension to the skid under the normal method of tensioning straps individually.

The advantages of the multiple tool strapping method seem to be these: (1) a better package; (2) reduction in wire usage, and (3) reduction in labor.

The second item under packaging is the vacuum carton sealer developed by Southworth Machine Co. for telescope cartons. We have had a certain amount of experience with pressure seal packages. Our efforts met with failure because the carton package was difficult.

Presented at the meeting of the Maine-New Hampshire Section of TAPPI, held at Whiteface, N. H., June 17, 1960.

The Economics of Unloading Railroad Car Shipments of Pulpwood

H. N. Bartley

H. N. Bartley

The Great Northern Paper Co. receives approximately 23% of its total supply of wood by water. It received approximately 19% of its total supply by truck; and finally 58% of its total supply or 444,000 cords, by rail. Rail delivered wood is on the increase due to improving shipping and unloading facilities. Among the species handled by rail deliveries are the following: rough and peeled spruce, peeled hemlock, peeled poplar and peeled hardwood (birch and maple).

The bulk of all the rail deliveries fall in the 4-month period from December through March. During this time unloading facilities and storage areas are jammed to capacity and many times beyond their capacity. The hardwood and poplar go to East Millinocket, the peeled spruce and hemlock to Millinocket and the rough wood to the Cape and North Twin. So we have at least four major areas for rail unloadings.

The following are the five types of cars that we encounter at our unloading spots. First we have the old fashioned box car. Second the open top box car or the so called 3500 series. Third, the steel rack. Fourth, the open top dump and last and newest the end rack dump car.

The B & A has the following number of cars of the aforementioned types available for pulpwood loading.

Steels	24
3500 series	100
Regular dumps	263
End rack dumps	266
Boxes (no limit on foreign cars)	30

This gives a total of 683 cars. The B & A expect to make 100 to 150 of the regular dumps over to the end racks this summer.

Let us now take each type of car and analize the advantages and disadvantages of each.

First we will consider the box car.

Advantages
1. No loss of wood in transit.
2. Do not fill with snow in winter.

Disadvantages
1. Must be loaded and unloaded by hand—more expensive.
2. More difficult to unload by hand than the other types.
3. Difficulty in accurate scale, discount, mixed species, etc.
4. Difficulty and danger in opening doors.
5. Must use drop cords for lighting on nightshift.

H. N. Bartley, Great Northern Paper Co., Millinocket, Mo.

View of open top car 3500 series loaded

Next let us look at the "steels" (mostly for logs).

Advantages
1. Can be loaded mechanically.
2. More easily scaled.
3. Easier to unload by hand and cheaper.
4. No wood loss in transit.

Disadvantages
1. Can be unloaded mechanically but best by hand.
2. Exposure to elements make winter unloading difficult.
3. Cost more to unload than dumps.

Next the 3500 series.

Advantages
1. Can be tumbled in or crane loaded if done with care.

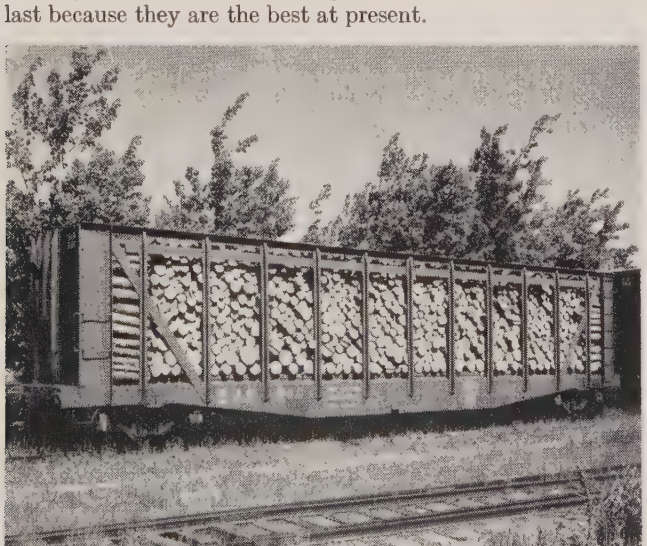
Disadvantages
1. Must be hand unloaded.
2. Fills with snow.

Next the regular two-door dump cars.

Advantages
1. Easily loaded and unloaded mechanically, tumbled in or piled in.
2. No wood loss in transit.
3. Because of ease in loading and unloading get quick turn around (24 hours).

Disadvantages
1. Fill with snow in winter—gravel from piled down areas in summer.
2. Trouble with big and small doors.
3. Hard to scale.
4. Limited to pulp and some sulfur.

Last, the new end rack dump cars. We have these until last because they are the best at present.



Steel car

View of open rack car of wood

Advantages
1. Cheap to build and maintain (BAR).
2. Easy to scale.
3. Easy to unload the year around.
4. Don't build up with snow or gravel.
5. Cheapest car to unload.

Disadvantages
1. Loss of wood in shipment.
2. Some crane operators dislike them because it takes longer and more care to load (holds more wood).
3. Only hauls pulpwood.
4. Break existing ramps.

Now, what do these advantages and disadvantages lead to. The fact that we want a cheap and efficient rail wood delivery system. Let us now look at some cost figures that show the advantages of the various types of cars and unloading.

The wood that is hand unloaded in the mill yards is done by the hour. All hand unloading done by the Woodlands Department is done on a piecework basis. Every unloader must, after a breaking-in period, better the daily rate or he is not kept on as an unloader. Our current rates for unloading are \$0.40 per cord for boxes and \$0.33 per cord for others. Our common labor rate is \$1.75 per hour and that of the mill is \$1.92.

Now if we forget fixed charges and consider only the difference in labor rates we have a difference of \$0.07 per cord for box cars over steels and dumps. Some men can unload five, six and up to seven cars a day but the average would be near three and the minimum two cars. A must unload 35 cords of the \$0.40 wood or 42 cords of the \$0.33 wood or any combination of the two up to a minimum of \$14, which constitutes a day's pay.

In order to unload 50 cars by hand daily we will require, in addition to our regular overhead, a locomotive operator, brakeman, etc., and the services of 15 to 18 cord unloaders. By adding one hydraulic car dumper we are able to unload up to 100 cars in 9 hr. or 11 cars per hour.

The difference in unloading costs is only one small part of the cost that can result from inadequate unloading facilities. We must maintain a balance between loading and unloading. You cannot unload 220 cars a day while you are loading 300 and keep your cost down. If you have too many empty cars available then you will overload your delivery points and demurrage will run your cost sky high. If you have a fixed number of cars then the shippers could be short at the sidings and the whole woods trucking operation is tied up. A happy medium is a must but it is often hard to obtain.

The use of the dump cars has enabled us to unload 150 cars a day mechanically, and get these cars back to the shipper the next day. It is not uncommon to unload the same car three times in the same week.

In 1950, we constructed a mechanical dumper at Cape

Dumping wood from car

View showing car in dumping position

Siding at a cost of $97,279, this included $7828 for a locomotive house. The breakdown of this cost was: grading $13,081, track work $14,706, electrical transmission line $4471, mechanical dumper $54,500, and miscellaneous $2700.

Some of the factors that influence the number of cars possible to unload on these mechanical dumps are:

1. Switching and physical limitations. The capacity of your switch engine determines the number of cars to be carried to the dumper at one time.

2. Visibility—The locomotive operator should be able to see the signals of the brakeman setting the cars on the dumper. A two-way radio might correct a situation contrary to this.

3. Size and convenience of sidings. We have one siding that limits our switching and dumping to five cars at a time. The other will handle more than double this amount. This saves time for dumping that is used up in bringing in loaded cars and dispersing of the empties.

4. The biggest and most important factor is determining the volume and speed of rail wood unloading in the carrier that handles the unloaded wood. In our case both of our car dumps are situated on the river bank. This is an ideal situation. In one area we can store 90,000 to 120,000 cards and the second area approximately 50,000 to 75,000 cords. A water carrier of this type is ideal except during the periods of extremely cold weather when heavy formations of ice prevent the wood from filling the available space. At North Twin we can crowd this jam of wood and ice down into the lake by opening the waste gates of the dam above and flushing the river. The success of such an operation depends on the amount of ice present and the amount of flow available.

The conveyer where we unload our hand cars can accommodate nine cars on a side or 18 cars at a time. These cars are unloaded into a button and cable conveyer, which handles this number of cars nicely. The wood drops directly into the river just upstream from car dumper. When our water storage area is filled we have to fall back on an antiquated stacker that is plain torture after the first 5000 cords.

In spite of the dump cars and hydraulic lifts, unloading gets to be quite a problem during the winter months. Most of our wood is crane loaded, this means that the peeled wood gets loaded into dump cars. Since the mill has to unload peeled wood by hand only half of the potential of these cars is being utilized. When there are no dump cars available for rough wood it may get loaded into box cars that must also be unloaded by hand. So we have a complete reversal of all our advantages. We, together with the B & A do our best to keep this situation to a minimum. This year the mill at Millinocket is revamping its entire rail unloading facilities in order to fully utilize the end racks.

It will have four, eight-car sidings with a flume between each set of two tracks. A version of the "grade all" will pull the wood from the end rack cars into these flumes. It will also be able to unload some of the side delivery trucks in the same manner.

To summarize this problem briefly one would say that at this time the most economical pulpwood car, both for loading and unloading, is the end rack dump car. We save approximately $9.00 per car on the dump cars over the hand loaded types. Keep a good balance of cars between shipper and unloading so as to keep the woods operations moving as rapidly as possible, and yet not overload your unloading and storage areas. Concentration yards for piling down on rail sidings may be necessary to keep this balance.

Presented at the meeting of the Maine-New Hampshire Section of TAPPI, held in Whitefield, N. H., June 17, 1960.

New England

The annual meeting of New England TAPPI was held at Chatham Bars Inn, Chatham, Mass., June 3–5, 1960, with the Eastern District acting as host. The technical program was as follows:

First Session, Friday, June 3

Moderator: Edson J. Ferrell, Crocker-Burbank Inc., Fitchburg, Mass.

1. "Latest Trends in Paper Requirements for the Three Principal Printing Processes," by Alex Glassman, R. R. Donnelly & Son, Chicago, Ill.
2. "Book Printing and Construction," by Walton C. Allen, Vice-President, Crocker-Burbank Papers, Inc., Fitchburg, Mass.

Second Session, Saturday, June 4

Moderator: John Lewis Bolton-Emerson Co., Lawrence, Mass.

1. "Adhesive Strength of Gummed Tapes as Measured by the Instron Tester," by Jack Keenan, Lowell Technological Institute, Lowell, Mass.
2. "Method of Quantitative Measurement of the Water Resistance of Starch," by Frank Zichelle, Lowell Technological Institute, Lowell, Mass.

Third Session, Saturday, June 4

Operations Research and Computers

Moderator: Joseph A. Theriault Continental Can Co., Uncasville, Conn.

1. "Introduction to Operations Research and Computers," by Philip Rulon, Harvard University, Cambridge, Mass.
2. "Profile of a Linear Programming Problem in the Manufacture of Boxboard," by Winston Riley III, CEIR, Washington, D. C.
3. "Computing Service Firms as a Tool of Industrial Management," by Arthur F. Phinney, CEIR, Washington, D. C.

SCHEDULE OF EVENTS

Friday, June 3

2:00 p.m.	New England Section Executive Committee meeting
3:00 p.m.	Ladies' reception and tea
3:00–5:00 p.m.	Technical program
6:00 p.m.	Reception
7:00 p.m.	Banquet. *Speaker:* ROY C. GUNTHER, JR., Manager of Technical Planning Missile Electronic and Control Division of the Radio Corp. of America, Burlington, Mass., who spoke on the subject of establishing a laboratory base on the moon
9:00 p.m.	Dancing

Saturday, June 4

9:00 a.m.	Student Award papers
10:00 a.m.	Technical program
12:00 M	New England TAPPI business meeting
9:30–12:30 p.m.	Ladies' Shuffleboard and ping-pong tournament
12:30 p.m.	Clambake
2:00 p.m.	Golf tournament at Eastward Ho
7:30 p.m.	Banquet
9:30 p.m.	Dancing

TECHNICAL PAPERS

"Latest Trends in Paper Requirements for the Three Principal Printing Processes," by ALEX GLASSMAN, R. R. Donnelly & Son, Chicago, Ill. (Abstract)

Mr. Glassman presented a very interesting paper in which he described present test methods and thinking of a large publishing house with respect to the requirements of papers currently used and those they expect to use in the future. By way of review, Mr. Glassman described the relief, planographic, and intaglio processes by means of colored slides and he described how all three of these were used at Donnelly. He also defined the relationship between letterpress printing quality and paper and the various properties of paper and ink in printing which are required to produce the highest quality.

The second paper by Allen follows this report.

Second Session. The two student papers introduced by John Lewis were presented on Saturday morning by two students from Lowell Technological Institute which described projects on which they had worked during their senior year. The first speaker, Jack Keenan, was the winner of the New England TAPPI award while the second speaker won the Helen V. Kiley award.

Third Session. This was devoted entirely to electronic computers, how they may be applied to paper industry projects, and was very interesting; creating a lively discussion period. The first speaker, Dr. Rulon from Harvard University, introduced the subject of computers by describing what computers are and what they are expected to do. The five important features one should look for are as follows:

1. Input speed and flexibility.
2. Program flexibility.
3. Memory speed and capacity.
4. Computing speed.
5. Output speed and flexibility.

The second speaker, Winston Riley III, described linear programming as a system of simple relationships of activities. He described a technique for the linear program for solving the problem of minimizing machine trim in a boxboard mill.

The third speaker, Arthur Phinney, described the services of CEIR who provide the largest computing service center in this country. This company has a very highly specialized staff of mathematicians, statisticians, and programmists. He described several typical problems that can be solved readily by computing techniques.

D. W. LOVERING, *Secretary*

Book Printing and Construction

Walton C. Allen

WE HAVE been brought up to date about current methods of printing by Mr. Glassman. You may be interested in reviewing with me the cycles of printing processes, publishing, and publishing papers in the past 40 years and how the future looks to me.

I am confining myself to the use of paper in books since that has been my experience. It has been my good fortune to have been associated with the Athenaeum Press of Ginn and Co. and the Norwood Press in the purchase and use of book papers and for the past ten years I have been trying to sell it for Crocker-Burbank. These years have meant association with more than 100 publishers in the use of paper.

Many a publisher has said to me that he wants to see how a sheet prints as well as how it looks. Likewise, unless the mill man sees how the paper prints and performs, it is difficult for him to determine what to offer.

CYCLES IN PRINTING

Forty years ago practically all books were printed letterpress on flat bed presses. There were a few Adams stop-cylinder presses printing on dampened paper but mostly books were printed 32 pages at a time on Huber-Hogeman and Miehle presses. In the middle Twenties perfecting presses printing back to back came into use printing up to 46 by 69 in. with 64 pages on each side and 128 pages on both sides. The speed of these presses averages 1200 to 1400 impressions a side an hour. Ben Day illustrations in color were printed on two-color presses on text paper while four-color process illustrations were printed on coated to be inserted by hand in the folded sheets.

Offset came into use in the early Thirties with the introduction of a series of readers by Row, Peterson. Donnelley was the printer. The soft, pastel colors made a favorable impression on school people and the demand for such books grew quickly. These presses could print on any surface of paper, provided it had a high enough lift. The first offset presses could only print 32 pages at a time, but since the grain had to be across the cylinder to minimize the effect of stretch, this meant that the grain was across the page. This was objectionable in books since it meant they would not lie open. Letterpress papers were made to have the grain up and down the page.

Newer offset presses grew in size and gradually were able to print four colors at a time. Sixty-four page forms called for heads or tops of pages to be imposed across the cylinder and the grain was finally up and down the page. Speeds were up to 4000 to 5000 impressions an hour for each color and far faster than letterpress. In this period the books were for the elementary and juvenile markets.

Some of the older trim sizes of books were $5 \times 7^1/_2$ (41 × 61); $5^1/_8 \times 7^3/_4$ (43 × 64); $5^3/_8 \times 8$ (44 × 66); $5^5/_8 \times 8^3/_8$ (46 × 69); 6×9 (49 × 37); $6^1/_8 \times 9^1/_4$ (50 × 38); $7^1/_{16} \times 10^3/_8$ ($57^1/_2 \times 42^1/_2$) and for workbooks $8^1/_2 \times 11^1/_4$ (46 × 69). There were no presses to accommodate 64-page forms of 6 × 9 and larger books until the introduction of 76-in. presses. Limitations of the number of pages printed at a time were increased by having illustrations bleed or run off the page.

Sheet fed and rotogravure presses have never fitted to any great degree in the book field. Sheet fed gravure presses did and can print halftones better than any other press, but the type also has a screen with a saw tooth edge. This cuts down readability. The small size of these presses and their slow speed, together with the expense of plates makes them economically unsound for production editions of books.

Rotogravure printing has great speed but this means larger editions than those usually available in books. Add to this restrictions in paper quality, difficulty in holding register

WALTON C. ALLEN, Vice-President, Crocker-Burbank Papers, Inc., Fitchburg, Mass.

of color, and the tone of color itself. Because of these limitations, I believe that this process holds little promise for the future.

Gelatine printing has been used for illustrations of some limited editions but this is not suitable for the popular run of books. Size and slow speed of presses also limit their use.

Silk screen is not adapted to the layout of book forms.

So we get back to the letterpress and offset processes. Both are in stages of radical changes both because of competition with one another and to meet the competitive demands of publishers. The greater amount of commercial printing promotes greater press developments, some of which publishers can use in their books.

There will continue to be demand for sheet fed flat bed letterpresses for type and electrotypes and one color offset presses for smaller editions of books. Charges for these will be kept competitive with one another. Increasing use of cold type, bright type, dycril, and other photo-polymer plates heighten the competition between letterpresses and those for offset.

The 76-in. rotary letterpress is competitive with the best in offset, especially with these newer, more efficient plates. These will run at speeds of 4000 to 5000 impressions per hour per color. They will give blacker, sharper halftones and control color better than offset presses. Process colors will be sharper than offset which may or may not be desirable to publishers according to their taste or requirements of books. Web attachments have been made for some of these presses. A handicap against greater use is that the grain of the paper will be across the page on standard size books. This is a stop gap arrangement for existing presses. Demand will dictate whether new letterpresses with integral web attachments will be built.

Letterpress plates will give hundreds of thousands more impressions than those for offset which give this process an economic advantage on books with long life and few changes.

Smooth surface pigmented and machine coated papers are required by letterpress for best halftone and process color printing.

In the effort to print better halftones and sharper color offset presses are also calling for smoother papers and better plates, such as the lithure. These newer plates also have longer life, though still not comparable with those for letterpress. There has been little progress in the development of dry offset.

Web letterpresses with folding attachments have been developed for paper back printing and now have an almost complete monopoly in this field. Strachan and Henshaw has now made a press for Houghton, Mifflin and has one in process for World Publishing for the finest quality book work. These have folding attachments.

Web offset presses with folders are the current rage. The one and two-color Webendorfer and Hoe presses have been in use for several years. Now there is great interest in the Hantscho presses for fine process color printing. Harris-Cottrell is also entering this market, within perhaps the next five years. Incidentally, it may interest paper manufacturers that the rate on four-color Hantscho presses in book work is expected to be $140 an hour. Charge backs for bad paper will be really expensive.

Both the web letterpress and offset machines are capable of running 1000 ft. or more a minute and are suitable like the sheet-fed rotaries for editions of 25,000 copies or more.

The offset process has spread rapidly into the high school and college fields as well as in illustrated trade books. Greater flexibility in use of papers and the expense of engraving over color separations for letterpress have encouraged the use of offset.

PUBLISHING CYCLES

The trade book field has seen relatively few changes except in the tremendous growth in paper backs. Like textbooks up to 30 years ago, trade books (those sold in book stores) were printed letterpress. Development of the offset process led to the printing of most juveniles by offset, especially those in two colors. Fiction and nonfiction books continue through the years to be printed letterpress, sometimes from type, sometimes from electrotypes on bulking papers. In recent years some reprints have been printed offset on tub sized letterpress papers.

Mention has been made of paper backs. These started in volume in the Thirties and have grown steadily. Most of them are reprints of case bound books but sometimes a publisher will issue case bound and paper back editions simultaneously.

Except for paper back, editions of trade books are relatively small and seldom require more than 10,000 lb. of paper at a time.

Greatest developments have come in textbooks. Thirty years ago elementary books had color in the text. Some of the high school books had colored inserts on coated papers. page sizes were small and halftones likewise were small and had little detail.

Increase in content, recognition of the value of visual aids, and the interest-compelling use of color revolutionized textbooks in the high school field. World sources were searched for more illustrative and dramatic photographs and then were reproduced in larger sizes with greater detail. Color was introduced both functionally and for eye appeal. Practically all high school texts are on pigmented papers for finer reproduction of halftones and color.

College books continue to be mostly in black but some enterprising publishers have increased page sizes, added illustrations and color. Greater enrollments in colleges have increased this market and publishers are using imagination and creative layout to attract attention to factual content.

Paper manufacturers are taxed to provide suitable papers for all three of these textbook fields.

Other publishing ventures are in encyclopedias, dictionaries, bibles, and reference books in general. More and more of these books are being planned to print from the web, both letterpress and offset. These are mostly "black" books except for encyclopedias.

PAPER CYCLES

There have been dynamic changes in paper manufacturing and paper itself in the past 40 years just as there have been in publishing and printing. Relatively new pulping methods and availability of hard woods, coatings and pigments have revolutionized paper for books as well as commercial printing.

In appearance the bulking papers for use in fiction and nonfiction books have changed little. Bulk and opacity are still the most desirable characteristics.

The need of keeping down cost of manufacture has led to the greater use of groundwood papers such as those made by Finch, Pryn.

More and more of these bulking papers are made as dual purpose grades which can be printed either letterpress or offset.

There have been radical changes and a wider range in the papers for textbooks. In the Twenties and early Thirties books had few if any halftones printed in the text and those that were small and with little detail.

English finish and supercalendered papers were most commonly used since practically all were printed letterpress. These were soft fiber papers until the mills began to use West Coast long fiber sulfites. These cut back on printing quality. Warren and Mead began to experiment with film coating the paper in the Twenties. Progress in securing smoother papers for letterpress has been continuous since that time.

Offset papers for books at first were hard and "tinny" with little concern for finish. The desire to approach the sharpness and blackness of letterpress halftones created a demand for smoother offset papers, both pigmented and unpigmented.

Also, a compelling force for thinner papers in offset and letterpress was the increase in number of pages in the books. Fifty-pound basis became the standard unless limited by specifications. Some anthologies and reference books with more than a thousand pages are printed on lighter weights down to 30-lb. basis.

The 750-page high school textbook can bulk no more than 1 in. because of binding charges. There is a demand for papers bulking 800 pages to the inch.

Opacity in paper is increasingly important with the addition of color and solids in the books backed by open text. State specifications have a minimum of 90 for 50-lb paper but even this is insufficient for most books.

Publishers of elementary and high school texts ask that the papers made for them meet State Specifications: Boards of Education in Southern States adopt books for their entire state and have set up specifications for the physical qualities of these books. The National Association of State Textbook Directors, American Textbook Publishers Institute, and the Book Manufacturers' Institute have drawn up these specifications. They have been recently revised to cover permanence, strength as represented by tearing and bursting tests, opacity, gloss as a measure of smoothness, and color.

Encyclopedias are another major part of the publishing market. Papers for web offset, machine coated for letterpress, English finish, and 30-lb. Bible are all used in volume.

Bibles, prayer books, dictionaries, and rate books provide business in papers ranging from 17 to 30 lb. basis with few sources of supply due to limited experience in lightweight papers, equipment, demands for pulp use, and knowledge of the market. Relatively the lightweight tonnage requirements are small.

Paper backs offer an expanding business to the paper manufacturer but in the low price field groundwood continues to be used in those volumes selling for 50 cents and less. Lately there has been a wide acceptance of low price free sheets for use in the so-called better class of paper backs which retail for as much as $2.50. Paper backs also create a demand for printing bristols.

The great workbook market is in the textbook field. New England mills are making vast quantities in tablet and offset or litho grades. These papers are lower in price than those used in standard textbooks.

Paper for books continue to be in various shades of white and off-white (natural or so-called "test" shades). Some colored paper has been used in teachers' editions to separate the teachers' section from the regular text. In the Thirties there was some demand for "eye-ease" colors of pale green and yellow for use particularly in bookkeeping texts.

Lately there has been the Faber Baren movement to promote the use of colored paper in all books. Publishers have been loathe to accept this because it is difficult to get the public to accept innovations. Some publishers feel that colored paper reduces the effectiveness of halftones and colored inks. Others say that there is still lack of proof that colored paper reduces eye strain—some argue that it increases eye strain. The final argument against greater use is its greater expense.

Publishers ask mills for a consistent product—consistent in bulk, in finish, in strength, in opacity. They build their books around the paper. The amount of cloth they use, the binding price they pay, the stamping dies they use are contingent on specified bulk of paper.

Sometimes they ask for variations from standards to accommodate their plan for a particular size book or package. Sometimes this can be done without compromising necessary printing qualities—sometimes not.

Publishers of trade books ask for quick service because their market is a temporary one. A book is often popular today and a dud tomorrow. The manufacturing pattern of some mills makes it difficult to provide the necessary service.

Publishers ask for a dependable source of supply. They ask for mills who can and will continue to manufacture papers which are suitable for their books. Mills which are in and out of markets are not too attractive to publishers, whatever the price concessions. The better and stronger publishers have been through several national emergencies when paper has been hard to get and they remember the reliable sources of supply.

THE FUTURE

New presses will create demands for newer papers and new sizes.

How wide will the webs be and sheet sizes?

That is a vital question for paper mills for a bad guess or estimate can be even more costly for the mill than the printer.

Presses used to cost $10,000 to $40,000. Today rotaries are $250,000 and webs run up to $750,000.

Paper mills invest millions in one machine.

My crystal ball tells me that the greatest demand in book papers will be in pigmented grades for offset and letterpress, whatever the process used in the manufacture of them.

Can a machine coated or pigmented grade be made sufficiently thin (0.0025 in. in 50-lb. basis) on the machine or off the machine and then with an opacity of 91 or better? Guess right on the process or you will suffer.

What size equipment? The standard sheet size for popular textbooks will continue to be 52 by 76 but as more of the presses have web attachments the web called for will be 76 in.

Some new web presses will be 38 in., some 54, some 63. Poor deckles are in sight unless a variety of equipment is provided.

There is nothing stereotyped about the book business. Patterns have changed frequently, especially in the past 10 years and probably the next ten will be even more dynamic and revolutionary.

Will we be ready for the challenge?

Presented at the meeting of the New England Section of TAPPI, held in Chatham, Mass., June 3–5, 1960.

Synthetic Fibrillating Fibers—New Materials for the Manufacture and Bonding of Long-Fibered Synthetic Fiber Paper

Hanns F. Arledter

Synthetic fibers possess inherent properties that make them interesting as raw materials for specialty paper manufacture. These man-made fibers potentially can impart to paper such highly desirable characteristics as chemical and acid resistance, superior strength, age resistance, and optimum electrical performance. Because the manufacture of synthetic fiber paper raises a number of problems during processing on conventional paper machines, however, the production potential for such papers has been unduly limited. New materials were needed to act as binders and for general improvement of the manufacturing conditions.

To this end, Hurlbut Research Laboratory has studied for over three years the papermaking properties of fibrillating organic synthetic or man-made fibers—for example, the acrylics (1); polystyrene, polyvinyl acetate, polynitrile copolymers (2); and viscose rayons (3). These fibers, manufactured according to specific methods, show a definite tendency to fibrillate; i.e., each filament tends to divide into many finer fibrils. Interestingly too, these fibrillated fibers possess latent inherited selfbonding properties.

The properties of papers made of acrylic fibrillating fibers developed by Chemstrand Corp. have been described in an earlier paper (*1*). This paper discloses a new synthetic fiber papermaking technique and describes properties of papers manufactured in pilot plant quantities by the new method and of laminates made therefrom. A future paper will report on a functional high strength synthetic fiber paper

Hanns F. Arledter, Director, Harlbut Research, The Mead Corp., Chillicothe, Ohio.

Fig. 1

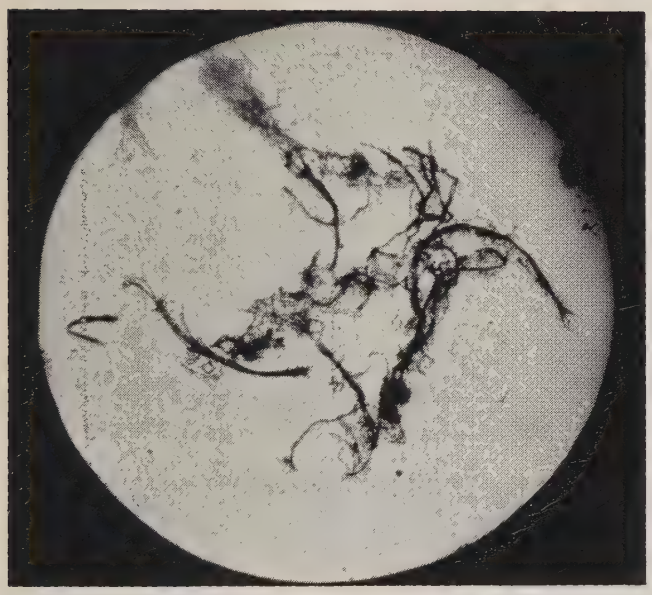


Fig. 2

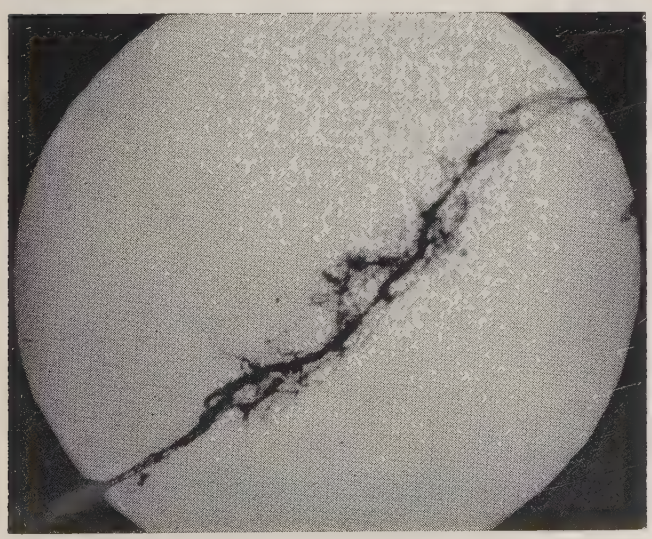


Fig. 3

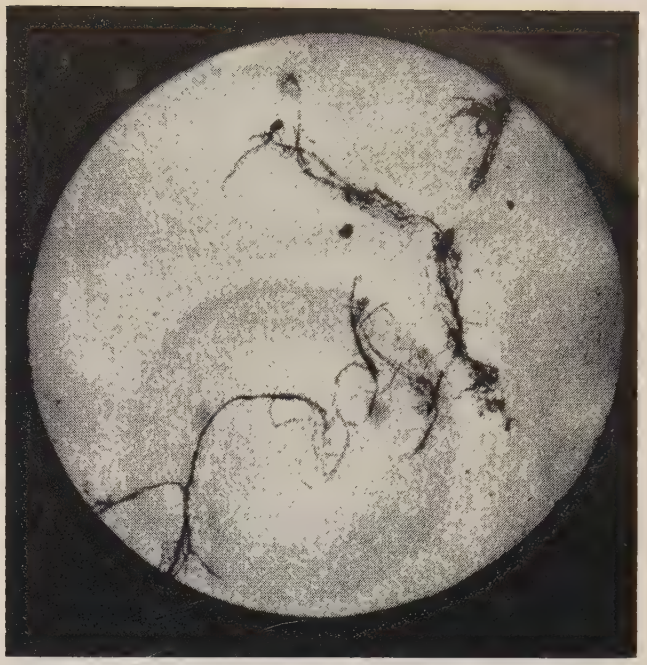


Fig. 4

produced by the fiber flock bonding method described in this article.

Table I shows how many of the fibers and fiber admixtures under discussion here behave during paper machine operations and in paper.

It can be seen that severe obstacles must be overcome to manufacture a paper of 100% conventional precut long organic synthetic fibers on conventional paper machines without the addition of supporting felts or rolls and without the use of supporting and bonding fibers and/or specific paper bonding techniques. Even the first reference (*4*) in the patent literature to synthetic fiber paper suggests the addition of well fibrillated cellulosic fibers or of colloidal substances 60 to 100% precut long synthetic fibers. Such additions minimize the manufacturing problems, facilitate dispersion and sheet formation, and increase the strength of the wet and dry paper web.

In a later development F. H. Osborne (*5*) added 2 to 10%

Fig. 5

of a fibrous cellulosic flock binder composed of microscopical fibrillae of less than 0.0025 in. in length and 0.27 to 0.44 μ in width to at least 90% precut synthetic fibers $^1/_8$ to 1 in. length. More recently, C. S. Francis (*6*) introduced admixtures of cellulosic papermaking fibers of papermaking length and water-insoluble, preformed, extruded, thermoplastic resin fibers (vinyl acetate copolymers) that are rendered tacky at higher temperatures. He bonded and crosslinked the resin fibers in the paper by heat and pressure without destroying the fibrous structure of the resin fibers.

Our studies of these fiber systems soon indicated that the cellulosic fiber or cellulosic fiber flocks addition methods could be modified by using well fibrillated thermoplastic synthetic fibers or fiber flocks instead of the cellulosic binder or glass carrier fibers (*7*). We established that for many applications the potential in electrical characteristics and chemical resistance is not realized when synthetic fibers are used in admixture with cellulosic fibers. Functional strength properties of precut long synthetic fibers in paper structures are also not developed when they are used alone or in admixtures with cellulosic fibers unless effective bonding agents are present.

Our synthetic fiber paper manufactured by the new technique essentially overcome these shortcomings. The new method calls for mixing 20 to 80% of suitable highly fibrillated synthetic fibers with 80 to 20% of some other precut long synthetic fibers, dispersing them in water, and depositing them on a wire much as regular cellulosic papers are produced. The "other fibers" can be: nonfibrillating precut synthetic fibers of any kind or composition such as nylon or glass; long precut only partially surface fibrillated fibers such as the acrylics; or fibers with surface swelling, such as polyvinyl alcohol.

In principle, the manufacturing techniques for the new fiber systems are identical to those used in the manufacture of cellulosic fiber systems are identical to those used in the manufacture of cellulosic fiber floc synthetic fiber paper.

Fig. 6

Fig. 7

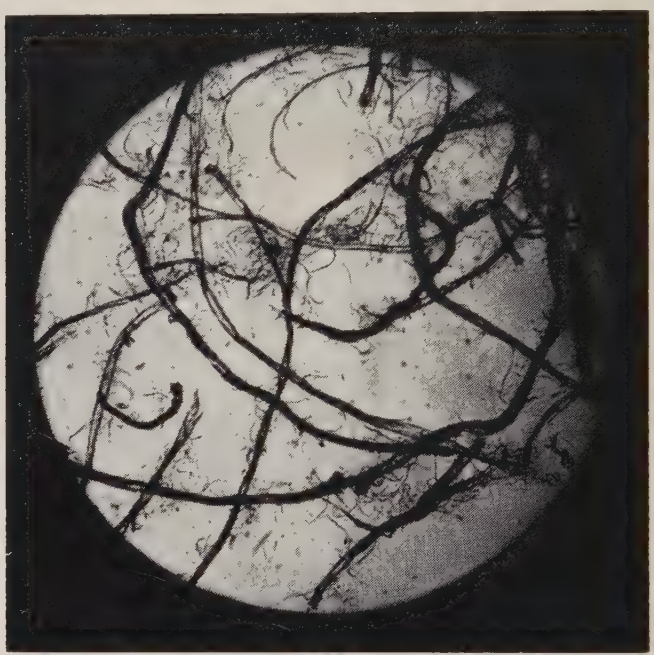


Fig. 8

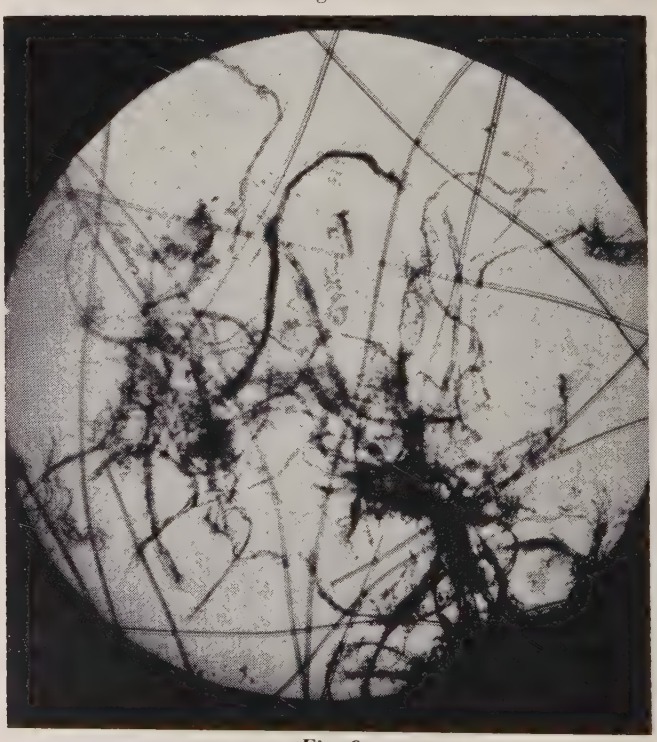


Fig. 9

Table I. Behavior of Fibers and Fiber Admixtures During Paper Machine Operations and in Paper

	Beaten cellulosic fibers, A	*Fibrillated synthetic fibers, B*	*Precut long synthetic fibers, C*	*Glass fibers, submicron and 1–3 μ*	*Admixtures of precut synthetic fibers and cellulose or fibrillated synthetic fibers*	*Admixtures of precut synthetic fibers and submicron glass fibers*
Fiber dispersion in water	Excellent	Very good to excellent	Fair to good	Good to excellent	Good to very good	Good to very good
Sheet formation	Excellent	Very good to excellent	Fair to good	Excellent	Good to very good	Good to very good
Filler, size, and binder retention	Good	Good	Very poor	Good to poor	Fair to good	Fair to good
Strength of wet paper web						
"Off couch"	Good to very good	Good to very good	Poor	Very good to fair	Fair to very good	Fair to good
"Off wet press"	Good to excellent	Good to excellent	Poor	Very good to fair	Fair to very good	Fair to good
Strength of paper web during drying on paper machine	Very good	Very good	Very good	Fair to poor	Good	Fair to poor
Fiber bonding on paper machine	Excellent	Excellent	None or poor (bonding needed)	Fair to poor (bonding needed)	Fair to good	Very poor (bonding needed)

The synthetic fiber flocks yield, however, improved properties in the paper and laminates, and lead ultimately to 100% synthetic fiber papers of high strength and overall chemical and physical properties not obtainable with papers consisting of unbonded mixtures of cellulose and synthetic fibers. The new method also overcomes, at least partially, the problem of insufficient strength of the wet or dry sheet on the paper machine and allows the reuse of wet and dry broke during the first steps of papermaking.

Our synthetic fibrillating fiber flock studies were carried out principally with two different kinds of fibrillating acrylic fibers and fibrillating polystyrene fibers. The degree of fibrillation obtained is shown in the photomicrographs, Figs. 1 through 10.

Figure 1 shows a fibrillating acrylic fiber before fibrillation treatment. The same fiber is illustrated in various degrees of fibrillation in Figs. 2, 3, and 4. Some fiber shows in Fig. 2, but only fibrils can be seen in Fig. 4.

A photomicrograph of another acrylic copolymer fiber at the start of the fibrillation treatment and after medium fibrillation is shown in Figs. 5 and 6.

For comparison and to show the degree of fibrillation possible with newer fibrillating acrylic fibers, Figs. 7 and 8 demonstrate, respectively, nonbeaten cotton linter fibers and cotton linter fibers fibrillated to a beating degree of 37 °SR.

The admixture of 20 to 50% or more or less of fibrillating synthetic fiber flock of the type shown in the photomicrographs to 80–50% of precut nonfibrillating or long, only slightly fibrillated synthetic fibers of 1/4 to 1/2-in. length has the beneficial effect of facilitating dispersion and sheet formation without affecting the properties expected from synthetic fiber paper.

The addition of the synthetic fiber flock also permits handling of the wet paper web on conventional papermaking equipment without the need of supporting felt or rolls.

A photomicrograph of the admixture of acrylic fiber flock and 1/4-in., 3-denier nylon fibers is shown in Fig. 9.

The properties of 100% *binder-free* synthetic fiber paper made of 0 to 100% fibrillated acrylic fibers and 0, 40, 70 and 100% 1/4-in., 3-denier nylon fibers are listed in Table II.

Table II. Properties of Organic Synthetic Fiber Paper LPM-Bonded with Fibrillated Synthetic Fibers Without Heat Calendering

	Fibrillating acrylic fibers, % 100	60	30	0
	Nonfibrating, precut nylon fibers 1/4 in., 3 denier, % 0	40	70	100
Basis weight (24 × 36—500), lb.	80	74.3	75.5	80
Thickness, mil	14	20	20	25
Tensile strength, g./in.	10800	4250	2600	0
Burst, lb.	22	12	10	0
Tear, g.	96	180	64	0

These papers were manufactured on a 9-in. pilot plant paper machine under conditions usual with regular paper machines. The 100% binder-free nylon paper could, of course, not be run under these conditions and the strength tests were concluded from handsheets.

In general, the superior functional strength qualities of the synthetic fibers, fibrillated or not fibrillated, are not realized in the shown paper structures if they are used alone or in admixture in paper and manufactured on paper machines in the regular way, unless heat and pressure bonding for the thermoplastic fibrillating fibers or the use of thermoplastic synthetic polymer binder for nonthermoplastic fibrous materials are employed.

Data shown in Table III indicate that the thermoplastic character of the fibrillating acrylic fibers employed permits bonding by hot calendering or hot pressing.

In many cases, this heat-pressure-bonding step need not be carried to conclusions so long as the resulting paper possesses the strength necessary for its particular application.

For example, an absorbent paper intended for laminates need only be strong enough to allow the resin treatment and the handling of the resin-treated product prior to lamination. The final phenolic laminate strength is solely a function of the type of fiber used, fiber length, and paper uniformity.

To prove this fact, Table IV compares the paper and resin laminate properties of a "strong" 100% cellulosic absorbent paper (0-2701) versus a "weak" long-fibered synthetic fiber paper bonded with 36% cellulosic fibers (0-2568-2).

The weak absorbent paper (0-2568-2) containing long precut glass fibers yields a laminate flexural strength of 27,500 p.s.i., and an impact strength of 9 ft.-lb. while the strong 100% cellulosic absorbent paper gives laminates with a flexural strength of 18,500 p.s.i. and an impact strength of only 0.7 ft.-lb.

Selection of the proper long synthetic fiber or carrier fibers for a given paper depends on the properties needed in the end use. Thus a paper made of an admixture of 60% fibrillating acrylic fibers containing 40% long precut nylon fibers

Table III. Influence of Heat Calendering on Strength of 100% Fibrillating Acrylic Fiber Paper (No Binder)

	Temperature, °F. 72	200	220	240
Basis weight (24 × 36—500), lb.	83	83	83	83
Thickness, mil	7.5	6.5	6	6
Tensile strength, g./in.	7800	10,300	14,500	18,800
Burst, lb.	21	40	48	59

Table IV. Paper Strength Versus Laminate Strength

Phenolic laminates: 46–48% resin; laminate thickness: 62–64 mil.

	Pilot Plant Grade No. 0-2568-2	0-2701
Paper properties		
Basis weight (24 × 36—500), lb.	80	80
Thickness, mil.	12	10.7
Tensile strength, g./in.	3000	13,200
Burst, lb.	9	33
Tear, g.	200	130
Laminate properties		
Flexural strength, p.s.i.		
Lengthwise	34,000	22,100
Crosswise	21,000	15,000
Izod impact strength, ft.-lb.		
Lengthwise	10	0.8
Crosswise	8	0.6

instead of 40% precut long acrylic fibers, in Table V, shows in a phenolic laminate, an impact strength of 2.4 ft.-lb. versus 1.0 ft.-lb. for the all-acrylic fiber paper.

It would be immaterial, though, which of the three paper grades to use, if the functional requirements of the laminates would have only requested electrical performance characteristics. All three laminates show excellent electrical tests.

How the type of fiber, choice of binder, and fiber length affect the paper and laminate properties is demonstrated in Table VI and Table VII. In all cases, fibers of papermaking length were used to obtain a true comparison between cellulosic paper and fibrillating acrylic fiber paper. The superior performance of the laminate made of binder-free fibrillated acrylic fiber paper compared to the poor results obtained with the other synthetic fiber laminates is partly due to the binder employed in the latter.

The results shown in Table VIII demonstrate basically the reason we suggest the use of binder-free admixtures of organic synthetic fibrillating fiber flocks in combination with long synthetic fibers of optimal characteristics. For many applications were good electrical properties and optimum laminate strength are required, cellulosic fiber bonding and short fibers in the synthetic fiber paper are defeating the purpose of using synthetic fiber in the first place. The use of fibrillating synthetic fibers in combination with long synthetic fiber is therefore a prerequisite for optimum results.

The process of beater addition of paper pigment fillers, sizes, binders, colors, etc., could not be applied to non-

Table V. Comparison of Phenolic Laminate Properties Made of Paper Consisting of Mixtures of Fibrillating Acrylic Binder Fibers of Papermaking Length, 1–3 Mm., and Long Fibered Precut Nonfibrillating Synthetic Fibers

Laminate thickness: 62–67 mil. Phenolic resin content: 47–50%

	Pilot plant grade no.		
Fibers employed	0-2983 *100% fibrillating acrylic fibers*	0-3001 *60% fibrillating acrylic fibers + 40% precut long acrylic fibers*	0-3368 *60% fibrillating acrylic fibers + 40% precut long synthetic fibers N*
Moisture absorption, %	0.15	0.25	0.11
Flexural strength, p.s.i.			
Lengthwise	23,100	16,800	24,600
Crosswise	15,200	12,100	18,900
Izod impact strength, ft.-lb.			
Lengthwise	1.07	1.10	2.7
Crosswise	0.81	0.9	2.0
Insulation resistance, megohms, C/96/90/40	10,000,000	10,000,000	10,000,000
Loss factor A	0.048	0.047	0.043
Loss factor D/48/50	0.065	0.065	0.083

Table VI. Paper Properties of Developmental Synthetic Fiber Papers Using Fibers of Beater-Cut Papermaking Length, 1–4 Mm.

	Pilot plant grade no.				
	0-3136	0-3486	0-3483	0-3375	0-2983-3
Fibers employed	100% cellulose	Glass	Nylon	Dacron	Fibrillating acrylic fibers
Papermaker binder, %	None	10	10	10	None
Basis weight (24 × 36—500), lb.	83	80	86	110	80
Thickness, mil.	11.6	19	33	33	14
Tensile strength, g./in.	7300	3200	1450	1600	9800
Brust, lb.	22.5	8	3.5	4.5	22
Tear, g.	119	56	40	44	140

fibrillating synthetic fiber paper to any significant extent, because of the difficulties of getting good particle deposition and retention on the wire. This technique can now be utilized successfully with fibrillating synthetic fiber paper alone or in admixture with nonfibrillating fibers.

The Hurlbut Research Laboratory has developed with this approach, all synthetic fiber papers containing a high amount of inert inorganic pigment filler, with paper properties outlined in Table IX.

Papers made of fibrillating synthetic fiber flocks in admixture with long synthetic fibers lend themselves readily usable for internal paper sizing and bonding with resin emulsion or latex, etc.

The combination of fibrillating thermoplastic fiber bonding with internally deposited resin or latex bonding becomes possible and permits, in addition, the use of nonfibrillating long thermoplastic fibers (*3*) and hot water soluble polyvinyl alcohol fibers (Fibribond) (*8*) for additional bonding effects.

From the combination of two or three methods of bonding described should result a different balance of mechanical web properties, which might allow widening of the scope of end uses of such 100% synthetic fiber papers for structures more closely resembling the nonwoven fabrics of the textile industry.

The possibility of adding fillers, sizes, and chemicals to 100% organic synthetic fiber paper should permit also the production of papers of more "paperlike" appearance and functions with all additional properties inherited from the all-synthetic fibers chosen.

CONCLUSIONS

Admixtures of beaten cellulosic fibers and cellulosic fiber flock and precut long synthetic fibers possess properties that allow production of papers on conventional paper machines. The Hurlbut Research Laboratory has demonstrated on a

Table VII. Comparison of Phenolic Laminate Properties Made of Synthetic Fiber Paper Using Fibers of Papermaking Length, 1–3 Mm., of the Nature of Cellulose, Fibrillating Acrylic Fibers, Nonfibrillating Nylon and Dacron Fibers and Micron Glass Fibers

Laminate thickness: 60–65 mil. Laminate phenolic resin content: 45–50%

	Pilot plant grade number				
	0-3136	0-3486	0-3483	0-3375	0-2983
Fibers employed	100% cellulose	Glass	Nylon	Dacron	Fibrillating acrylic fibers
Papermaker binder, %	None	10	10	10	None
Moisture absorption, %	1.19	0.15	0.33	0.22	0.15
Flexural strength, p.s.i.					
Lengthwise	21,900	20,200	20,300	17,400	23,000
Crosswise	15,300	19,800	16,200	16,300	15,200
Izod impact strength, ft.-lb.					
Lengthwise	0.85	0.58	1.09	2.43	1.07
Crosswise	0.72	0.52	0.86	2.05	0.81
Insulation resistance, megohms C/96/90/40	5600	950	225,000	3200	10,000,000
Loss factor A	0.1	0.27	0.077	0.09	0.05
Loss factor D/48/50	0.39	0.56	0.2	0.17	0.065

Table VIII. Development of Laminates of High Impact Strength Made of Paper Consisting of Fibrillating Binder Fiber

Laminate thickness: 60–65 mil. Phenolic resin content: 42–45%

Papermaker binder	100% fibrillating binder fiber A of papermaking length None	Fibers used: 80% fibrillating binder fiber A + 20% precut synthetic fiber B None	Fibers used: 36% fibrillating binder fiber A + 64% precut synthetic fiber B None
Laminate properties			
Flexural strength, p.s.i.			
Lengthwise	21,900	24,000	34,900
Crosswise	15,300	17,100	21,000
Izod Impact Strength, ft.-lb.			
Lengthwise	0.85	1.63	10.7
Crosswise	0.72	1.3	8.0
Paper properties			
Basis weight (24 × 36—500), lb.	83	81	80
Thickness, mil	11.6	14.8	12
Tensile strength, g./in.	9700	7300	3000
Burst, lb.	24	22	9
Tear, g.	115	240	200

Table IX. Properties of Paper Made of Fibrillating Synthetic Fibers and Inorganic Pigment Filler

	Pilot plant grade no. L-3397	Pilot plant grade no. L-3326
Inorganic filler, %	0	47.6
Paper properties		
Basis weight (24 × 36—500), lb.	103	130
Thickness, mil	16	17.5
Tensile strength, g./in.	10,800	8300
Wet tensile strength, g./in.	5,500	4000
Burst, lb.	19	18
Tear, g.	148	86

pilot plant paper machine that superior papers can be prepared from admixtures of fibrillated organic synthetic fiber and long synthetic fibers. Such fiber combinations should be useful materials in the manufacture of 100% all-synthetic fiber paper with a new range of paper properties and end uses.

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Presented at the meeting of the New England Section of TAPPI, held at Chatham Bars, Mass., June 6, 1959.

The assistance of the author's co-workers, especially Joseph Szewczak, Sam Huggins, and Vic Biasin, in preparing the papers and photomicrographs reported herein and the testing of the same, is gratefully acknowledged by the author.

Ohio

The Ohio Section of TAPPI held their annual Ladies' Night Program at the Hartwell Country Club in Cincinnati, Ohio, on May 12, 1960.

A social hour sponsored by 32 paper mill affiliates preceded the dinner. There were 422 people in attendance at this meeting.

After dinner a short meeting was held at which time the chairmanship on the Ohio Section was turned over to Charles S. Sweitzer of the Diamond National Corp.

Exchange of gavel from Virgil Perry to Charles Sweitzer, new chairman of the Ohio Section

Harlan Vogel of the Cincinnati Gas and Electric Co., who was in charge of procuring the entertainment for the evening as well as many other important details, then introduced two Barbershop Quartets. One group was composed of four men, the other of four lovely young ladies. The quartets gave renditions of their favorite melodies.

Following the entertainment, the members and guests enjoyed an evening of dancing.

GEORGE MARTIN, *Recording Secretary*

Pacific

How Industry Is Utilizing the Forest—Past, Present, and Future

Carl Garey

THE pulp and paper industry owns and operates approximately 50,000 sq. miles of forest land in the United States (*1*), a substantial portion of which is in the Douglas-fir region of the Pacific Northwest. Ever since the establishment of the forest industry in the Douglas-fir region, steady progress has been made toward more complete utilization of the forest. The growth and expansion of lumber and plywood and the development of the pulp and paper industry all attest to the steady, if not spectacular, growth of our wood-using industry in this region. Perhaps we can better appreciate the tremendous improvement made in the field of forest utilization in the Douglas-fir region during the past two decades, if we regress briefly and discuss the status of utilization during what I have chosen to call the "prepulpwood era."

Lumbering was the mainstay of the wood-using industry during this period of industrial growth and development. Production was generally limited to the traditional solid wood products of the day such as construction timbers, lumber, siding, paneling, flooring, roofing, poles and piling, and the like. Consumer acceptance was limited to only a select few of the coniferous species which occur in our forests. Western red cedar and Douglas-fir, by virtue of their abundance, size, and physical characteristics, became the value leaders while other associated conifers and hardwoods found a

CARL GAREY, Manager, Skykomish Tree Farm, Weyerhaeuser Co., Longview, Wash.

limited market or no market at all. To protect product quality standards, log grade requirements were harsh and strictly adhered to and since large diameter logs generally produce a higher percentage of the better grades of solid wood, log grading rules and dollar values favored large logs at the expense of small ones. Consider what this meant in terms of forest utilization; logged off land was a sight to make today's woods manager shudder. Logging debris completely covered the ground in a thick, impenetrable mat. Snags and defective green trees stood everywhere. It is understandable that, under these conditions, fire, either deliberately set and controlled or accidental and wild, was a necessary corollary to logging.

Contrast this with a typical clearcut under present conditions. It is not unusual to find logging slash so light that slash fires will not travel over the ground. We like to think that even woodpeckers must carry lunches when entering today's clearcut.

Experience indicates that the lumber shipped from a mill represents less than one half of the solid wood content delivered as logs to the mill pond (*2*) and not more than 40% of the wood content of the standing tree. The first big improvement in solid wood utilization came with the development of the dimension stock industry where, for the first time, the short lengths and narrow strips which accumulate in lumber manufacture, could be edged and end glued and made suitable for remanufacture into a variety of small products. Dimension stock, in conjunction with the large scale development of veneer and glue laminated products have improved whole tree utilization from 40 to 70% or better.

It is important to note that logging waste has a very real cost value to the wood-using industry to the extent that the variable costs of ownership and production can only be recovered on the volume of wood actually utilized. Poor utilization had the net effect of creating relatively high unit costs both in the production and conversion phase of the industry. In self-defense, the industrial forest manager practiced economic tree selection or, what is commonly called, high grading. Questionable trees or logs were left where found so that production cost would not be incurred on wood which might be refused or culled at the mill. The narrow definition of merchantability had a pronounced effect upon forest land and immature timber values since the conversion return from this source was necessarily deferred to allow immature timber to reach minimum merchantable size which resulted in an unreasonable accumulation of business risk and interest on the capital invested. High grading and the "cut out and get out" philosophy of the lumbering era were two of the simple economic facts of life which govern the wood-using industry.

The preceding statement has been an all too brief appraisal of the utilization standards which prevailed during the lumbering era. It is interesting to compare these practices with the standards of utilization that we know and observe today.

No one will question the impact that the growth and development of the pulp and paper industry has had on today's forest utilization practices. Thanks largely to the pulp and paper industry, the age of cellulose forestry has arrived. Equally as important to the improvement in whole tree utilization, has been the development of the integrated plant site where, for the first time, all of the products of the forest could be delivered, sorted, and routed to a manufacturing facility which would convert the raw material to achieve the highest possible product value. Inherent in the pursuit for the intergration of manufacturing facilities was the need to recognize the intrinsic value of various tree species for, in an intergrated plant, each log is likely to be more completely and appropriately used. High grade logs which can produce high value, solid wood products are converted to these conventional products. Lower grades of logs and defective logs can be stripped of their clear portion and the remainder routed to other facilities for further processing, and so forth down to and including the log suitable only for pulping.

The conversion of wood to fiber has had a startling effect upon forest management activities. A whole new terminology has evolved to describe the products of the forest. We now recognize pulp logs, wood logs, thinnings, and random length cordwood as products to be derived from the harvest and preharvest cut. The acceptance of these raw material products of the forest has forced changes in methods of measuring and handling the material. We frequently compare units and air day tons of chips with cords, cubic feet, and pounds of round wood. Scale by weight has become an acceptable method of measuring small, random length wood which defined conventional methods of measurement. The term pulp log has been defined to permit identification and measurement in terms of chip content.

While logging was logging until a few short years ago, today's forest land manager must recognize a variety of harvest and preharvest operations to supply a steady flow of the proper grade and species of wood to meet the diverse requirements of an integrated plant site. Gone are the days when huge steel-towered machines logged an entire quarter section from one location, selecting only the trees which met their rigid requirements. The loggers of that era considered that anything which reached the landing in one piece was worth shipping and, since only the large sound logs could withstand the pounding, their judgment was seldom questioned. The harvest and preharvest cutting preformed today is designed to satisfy three important requirements; improve current yields, reduce timber losses, and influence future growth. taken collectively, these three objectives are designed to maximize the rotation yield of the forest property.

The mature timber harvest is as carefully planned and executed as modern machinery and technology can make it. Where various sizes and species of trees are found in mixture, a prelogging operation may be required to remove the understory trees for pulpwood and small sawlogs before the large trees are felled. Large, high value trees are frequently pulled over with a tractor where normal falling would result in excessive breakage. Salvage logging with light, relatively inexpensive equipment frequently follows the old growth harvest to pick up the small logs and poles which could not be economically handled by the larger equipment. The term salvage logging is frequently extended to include harvest operations conducted on old cutovers where the residues from the original logging still have a value. These residues take the form of snags, scattered poor quality green trees, and logging leftovers and they are generally removed in advance site preparation work where the salvage logging activity can be made to contribute to the establishment of a new stand.

Preharvest cutting may be conducted in timber stands of all age classes. Preharvest cutting in mature or old growth timber is generally referred to as sanitation-salvage logging and is designed to accomplish two objectives; first, to remove and utilize dead standing or down timber and poor risk trees which will be lost to decay before the stand can be clearcut and, second, to prolong the carrying capacity of the stand or the period of time that mature timber can remain on the stump before mortality losses become excessive. To the extent that sanitation-salvage logging is successful in minimizing current and future mature timber losses, clear cutting operations in these stands can be regulated to fill the gap or span the years required for immature stands to reach economic maturity. This "stretch out" or storage of mature timber on the stump is tremendously important to the industrial forest owner who must face the problem of sustaining an annual cut while maintaining the proper balance between the size and quality requirements of an intergrated utilization facility.

You will notice that these management objectives and the cutting methods used to implement them are predicated upon two essential points: one, that we utilize the entire forest

crop from seedling to maturity within the realm of economic possibility to achieve the greatest possible yield of high quality wood and, second, that our preharvest and salvage operations be designed to improve upon the quantity and quality of future forest yields. Perhaps the best example of how these objectives are being met is in the preharvest cut in immature timber or what we refer to as thinning. Today's young stands of second growth timber constitute the allowable cut of the future and anything we do or do not do to manage these stands will have a direct bearing on the quantity and quality of our future wood supply.

Speaking of the Douglas-fir region in particular, second growth management is on the one hand, mature, and, on the other hand, an infant. The theory and development of second growth management concepts goes back hundreds of years in European culture while the practical application of this concept in the Pacific Northwest dates in our life time. The theory is relatively simple but the commercial application is extremely complex since it involves all of the common and many peculiar problems of production plus the intricacies of the biological rules which govern the life cycle of a tree.

Thinning is designed to establish control of tree to tree competition by removal of the surplus trees. Marking rules usually require that the better formed, faster growing stems be reserved for future crop trees and that the poor formed, slow growing stems be removed. To the extent that the root and crown systems of the leave trees are capable of utilizing the added increments of growing space, average annual growth will increase. In any event, thinning will remove and recover for use the volume of wood which would normally be lost to decay and place future growth increments on select, high quality trees.

Early attempts at commercial thinning were generally restricted to second growth stands which were old enough and large enough to produce such conventional and marketable solid wood products as sawlogs, smelter poles, hop poles, and piling. Recent improvements in woods equipment, added experience, and improved markets have made thinning economically possible in the younger age classes where the sawlog, as a product of the thinning operation, is more the exception than the rule. The acceptance of random length pulpwood scaled or measured on a weight basis was of paramount importance to the thinner of young second growth stands. Eight-foot cordwood, which was generally accepted at this time as a minimum specification for small wood, proved to be the straw that broke the camel's back. Coupled with the added cost of operation under the usual requirements of a thinning, the small diameter of the average tree marked for removal and low volume yields per acre, the slow and expensive process of cutting and loading eight foot wood, made the entire thinning operation submarginal. The operational problems which developed in thinning young stands focused attention on the importance of the efficiency of men and machines and the necessity for strict management regulation and on-the-ground inspection to hold damage to the leave trees at a minimum. Efficiency in the woods meant light, relatively inexpensive equipment, easily moved and quickly adaptable to meet varying conditions and operated by experienced men who were willing to consider that the effect of their activities in the woods was equally as important as daily production. This meant careful location of skid roads, skilled fallers who could drop a tree in a crowded stand without bruising its neighbor, restricting the use of tractors to carefully located swing roads, and using horses wherever possible to skid logs to the swing roads. If accessibility is a problem of the management of a thinning program, all-weather roads suitable for cheap log truck transportation must be built with consideration for future logging problems and at a cost which can be quickly recovered on a limited volume.

A commercial thinning, like any other business operation, must be capable of paying its way. To the extent that the market price paid for thinning wood equals or exceeds the sum of fixed and variable costs, the thinning has been an economic success considering that certain of the benefits to be derived from this form of stand improvement will accrue in the future. These long-term benefits include the reduced risk of insect, disease, and storm damage, accessibility to expedite the recovery of future natural mortality should it occur, the placement of all future growth on the best quality trees and, equally as important, today's permanent improvements will contribute to a reduction in future stand management costs to the extent that landings are established, truck, skid, and swing roads built, and the property lines and corners are fixed and permatized. New pulping processes which utilize hardwoods as components of both kraft and semichemical pulp have expanded the list of commercially acceptable wood species to include almost all of our important hardwoods. The process of broadening the species base has been of direct benefit to the woods manager who must handle these species in the harvesting operation whether commercially acceptable or not. This is of particular importance when commercial and noncommercial species occur in mixture as is frequently the case on the better sites at the lower elevations in the Douglas-fir region.

Statisticians and economists have projected an ever-increasing demand for wood products in the future which is in part based upon a growing population. This same population, which can be statistically tallied and economically counted upon to consume more of our products in the future, can also be counted upon to require more of our better growth potential forest land for homesites, highways, pipelines, dams, and recreation areas. The Secretary of Interior recently stated the "nearly $1^1/_4$ million acres of good farm land are lost each year to airports, highways, and factories and by the year 1957, 20 million acres of today's farm land will be used for other purposes. Mr. Gruenfeld of the Weyerhaeuser Co. recently pointed out that Washington and the other Pacific Coast States have been and will continue to be harder hit by population growth than the national average. Weyerhaeuser Co., in western Washington alone, has lost more than 1300 acres of forest land per year for the past four years to various public agencies and this makes no allowance for the additional loss of forest land due to urban encroachment (*3*). This loss will ultimately reduce our allowable cut by 1 million board feet per year.

Industrial forest management is striving to translate the intergration of conversion facilities into more complete forest utilization. To the woods manager and plant manager alike, this means better coordination of the raw material supply such that the long term problems of growing and harvesting a forest crop are recognized in the day by day shifts in the demand for logs, chips, and pulpwood. Industrial intergration has not been entirely a blessing for we realize that the widespread use of bark-free sawmill residues for chips has had a restrictive effect upon the demand for small log pulpwood produced from thinnings.

On the other hand, industrial intergration has provided us with the means of increasing the total dollar return from each acre of forest land largely as a result of the interplay of two factors; first, utilization has improved in the woods because we can remove and use more of the gross volume of wood which grows there. Taking advantage of this improvement in forest utilization is not without added expense however, for it costs more per unit of volume to multistage log, that is, relog, prelog, or thin, than does a single stage operation and, second, total dollar return per acre is increased because each log or portion of a log can be converted to achieve the highest end product value.

With the cost of delivered pulpwood equal to approximately 50% of the total cost of pulp and with the pulp industry unable to use an estimated 20 million tons of lignin annually (*4*), it would seem essential that we look to applied forest management in conjunction with forest research to provide

the high yield, low cost raw material which our intergrated facilities must have. Forest managers are dealing with this problem on an ever-increasing scale as they apply the tools and skills which research has tested and proved. Large scale regeneration and rehabilitation programs are planned or in progress today because direct seeding and aerial brush control are practical tools. Five years ago, direct seeding was in the experimental stage, while today we are seeding thousands of acres using helicopters to disseminate the seed at a fraction of the cost of hand planting. Last year Weyerhaeuser foresters alone collected 193,000 bu. of cones which will produce 50 tons of seed worth approximately $1,000,000 (*5*).

Research has developed and tested many chemical brush retardants to produce a desirable combination of selectivity and potency which will permit economic control of the nonproductive brush species. Hundreds of acres of high productivity forest land are being reclaimed each year to support and expand the sustained yield potential of our industrial forest property. Continuing research in forest genetics, forest soils, insect and disease problems, wildlife biology and related fields will permit us to exercise an ever increasing degree of control over our forest production to reduce waste and supply the type of wood which will best meet our needs in the future.

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Presented at the meeting of the Pacific Section of TAPPI, held in Bellingham, Wash., April 29, 1960.

Sawdust and Shavings for Pulp (Abstract)

G. H. Chidester

Extensive developmental work on saw designs shows promise for obtaining sawdusts of larger particle size than of those nor produced and hence more suitable for use in pulp manufacture. As basic to the pulping of sawdust and shavings, the Forest Products Laboratory has undertaken studies on the characterization of sawdusts and shavings from several sources. Experimental sawdusts include samples prepared from loblolly pine with a circular headsaw operated with bites per tooth of $^1/_{16}$, $^2/_{16}$, $^3/_{16}$, and $^4/_{16}$ in. to show the effect of this variable on particle size.

Samples of commercial sawdusts were collected from specific operational points. These include headsaws and edgers operating on Douglas-fir, ponderosa pine, western red cedar, white fir and white pine, western larch, southern yellow pine, and hard maple. Planer shavings include those from Douglas-fir, western hemlock, and ponderosa pine.

The particle size distribution in the sawdusts and shavings is determined by screen classification; and fiber length measurements are made on sulfate pulps prepared from the screen fractions. Four screens are used, having meshes of 2, 4, 8, and 16.

Strength and fiber length measurements have been made on loblolly pine sulfate pulps prepared from $^5/_8$-in. chips, sawdust chips retained on a $^3/_{16}$-in. mesh screen, and sawdust chip fines that passed through this screen.

The commercial sawdusts varied considerably in particle size distribution. For all samples, the amounts that passed through the 16-mesh screen ranged from 7.4 to 42%, the average being 33%. For comparison, this fraction averaged as low as 8% for experimental samples obtained with a circular headsaw operated at $^1/_4$-in. bite per tooth.

The results show that the weighted average fiber length of this finest fraction of softwood sawdusts is at the top of the range of hardwood sulfate pulps. The fiber length of softwood sawdusts obtained in sawing at a bite of $^1/_4$-in. per tooth may range up to 90% of that of $^5/_8$-in. standard pulp chips. Sulfate pulp made from a 5-mesh fraction of loblolly pine sawdust obtained at $^1/_4$-in. bite per tooth had about 85% of the strength of pulp made from $^5/_8$-in. pulp chips.

Presented at the meeting of the Pacific Section of TAPPI, held in Bellingham, Wash., April 29, 1960.

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Virginia-Carolina

The Virginia-Carolina Section of TAPPI held its business meeting the evening of May 20, 1960, in Wilmington, N. C., and on the following day toured the Carolina Div. of Riegel Paper Corp. at Acme, N. C. Eighty-one persons from Washington, D. C., south to Wilmington attended.

The Friday evening program held in the Azalea Room of the H & W Cafeteria featured a hospitality hour, dinner, election of officers, and the presentation of two technical papers.

Officers elected for 1960–61 were: Chairman, Roy F. Traver, Union Bag-Camp Paper Corp., Franklin, Va.; Vice-Chairman, Garland T. Edmonds, Chesapeake Corp. of Virginia, West Point, Va.; Secretary-Treasurer, John W. Gladstone, Halifax Paper Co., Div. of Albermarle Paper Manufacturing Co., Roanoke Rapids, N. C.

Ross Miller, Continental Can Co., Hopewell, Va., is the outgoing chairman and Traver and Edmonds served as vice-chairman and secretary-treasurer, respectively, during the past year.

C. E. Hartford, vice-president and general manager of the Carolina Division of Riegel, was recognized at the dinner meeting, after which James D. Wethern, manager of Manufacturing services, discussed the details of the Riegel Mill tour scheduled for Saturday morning.

O. E. Paynter of the Hazelton Laboratories, spoke on "The Paper Industry and the FDA" and Thomas Johnson, Quality Control Supervisor of Riegel, presented a paper on pump mill quality control.

The meeting was concluded Saturday at noon, after the guided tour of the Riegel plant facilities.

Fifth

Deinking Conference

of the

Technical Association

of the

Pulp and Paper Industry

Conway Hotel

Appleton, Wis.

Oct. 5–7, 1960

CYLINDER BOARD SESSIONS

45th Annual Meeting of The Technical Association of the Pulp and Paper Industry

NEW YORK, N. Y., FEB. 23, 1960

Application of Cylinder Wires in the Paperboard Industry

N. O. WEIL

THE use of what is known as cylinder wire cloth is certainly important to paper mills. It is used in so many ways and places in the handling of and the washing of all kinds of pulp.

In days gone by phosphor bronze was used almost exclusively. Then came the introduction of monel metal. This was followed by the introduction of stainless steel in type 304, then type 316, and with the use of the chlorine dioxide process type 317. Believe me, the ever-changing processes used by you paper makers keeps a wire cloth company, such as ours, on the jump. Our daily stock of the many and varied specifications you use runs into a considerable, very considerable inventory.

In a general way we can say to you that the largest calls for cylinder cloth are in 12 and 14-mesh backing wires and in 30 and 40-mesh facing wires. Also, the 24 x 18-mesh cable weave on the first washers on which a couch roll rides is becoming increasingly popular.

In the old days the common and perhaps the widest cylinders were 10 and 12 ft. Production, more efficiency, and lower costs and the first thing we found out was that we had to weave the wire cloth up to 204-in. wide to cover 16-ft. face cylinders. Now it has stretched to 250-in. width to take care of 20-ft. face cylinders. The trend surely has been towards wider machines. However, in talking with machine manufacturers I doubt that they will go wider than 20 ft.

In addition to the plain weaves mentioned there is also a cloth known as Dutch weave or corduroy cloth. The usual specifications are the 12 by 64-mesh which gives an approximate 40-mesh separation and the 15 by 88-mesh which is in the 50 to 60-mesh range. This type of cloth being heavy and firm eliminates the necessity of using a backing wire. Quite a number of mills like these Dutch weave specifications.

The type of seams to use in affixing cylinder cloth to cylinders is up to the individual mills. Quite often a lap joint will suffice where a continuous sheet is not necessary. In other cases a sewed seam is preferred—especially when using stainless wire cloth. Then there are cases where a brazed seam is preferred. The matter of seaming is up to the mill preference and experience.

We recall years ago of having mill operators talk of souring a wire; of flushing it with acid. Thank Heavens this idea of cleaning a wire with acid is being replaced by alkaline cleansing solutions. We think of a Kalamazoo mill which complained of short wire cloth life. By delving into mill operating conditions we found that at the end of the week they would wash up their cylinder wires with acid. Then over the week end that acid went to work on the wire cloth and in a short time what looked like lace curtain material was left. We prevailed upon this mill to wash up a half hour before starting up Monday morning. From then on there was no wire cloth problem.

As for putting on wire cloth covers on cylinders, just think of violin strings or the drum the fellow beats in a band. The covers must be put on tight—not slightly tight but very tight. If any play is allowed to take place wrinkles may develop; the cloth may breathe and less than normal life will be found.

When you use bronze cylinder cloth both the warp and the shoot wires must be made of bronze—phosphor bronze. In a fourdrinier wire the warp wires are phosphor bronze and the shoot wires are brass. In cylinder wires, both warp and shoot wires should be bronze. We have seen so-called bronze cylinder wires with brass shoot wires disintegrate because something in the solution attacks the brass. Phosphor bronze is a copper-tin alloy while brass is a copper-zinc alloy.

I think that about tells you the story regarding cylinder wires.

N. O. WEIL, W. S. Tyler Co., New York, N. Y.

The Practical Aspects of Microorganism Control in Cylinder Board Mills

J. J. DIETZEL

THE papermaking process in general provides an environment which is highly conducive to the development of slime-forming microorganisms. Because of the characteristics of operation, furnish, and sources of water, most cylinder board machine systems have a high degree of slime potential which requires the diligent application of thorough and methodical housekeeping practices and sound microorganism control. Each operator should review his microorganism control program critically in order to determine the degree to which slime control is profitable to his company through increased production and overall efficiency of mill operation. After the actual and potential losses have been estimated, a sound slime control program can be initiated by eliminating, or at least minimizing, these losses in each phase of the operation.

Many operators have long recognized the benefits from an effective microorganism control program and are enjoying increased production with greater customer acceptance of their products. However, there are still a few operators who take the attitude that, as long as there are not too many breaks and slime holes, everything is under control.

It is the purpose of this paper to review some of the more important factors which influence the growth of microorganisms, as well as some of the problems attributed to microorganisms when they are not controlled. It is well to think about these factors constantly, because the maintenance of maximum efficiency of operation and high quality of product is dependent upon the recognition that effective control of microorganisms is an economic necessity and not a necessary evil.

The uncontrolled growth of microorganisms which may

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result from the utilization of an ineffective toxicant or the use of inadequate amounts of an effective toxicant may cause the following important types of losses during the manufacture of paperboard, as given by Stitt (*1*);

1. Loss in stock quality and uniformity.
2. Lost production time.
3. Decreased equipment performance.
4. Loss of heat, chemicals, filler, fiber, and water.
5. Loss of finished product and customer acceptance.

As stated previously, most cylinder machine systems provide an environment that is highly conducive to the development of microorganisms, because all or more of the essentials for growth are present. Waste paper usually supplies an abundance of microbiological contamination along with an adequate supply of nutrients. Waste paper may carry with it a wide variety of bacteria and molds. It has been demonstrated that these are nonpathogenic organisms, but many are potential creators of slime and odor. Paper stocks containing glue, casein, starches, gums, or other related organic sizing or binding agents provide a rich, nutritional medium for the growth of microorganisms. Many of the nutrient materials may not be solubilized completely and thus contribute physically to the formation of cohesive masses composed of fibers, debris, sand, scale, rust, etc.

Once the microorganisms are present in the system, they become entrenched and adapt themselves to the specific environment and flourish in "dead spots" such as slow-moving or stagnant stock in pipelines, chests, headboxes, etc. When one realizes that some bacteria have a reproduction cycle of approximately 20 to 30 min. under favorable conditions, it is easy to understand how a system can become highly comtaminated in a relatively short period of operation if adequate control measures are lacking.

Certain grades of board require the use of chemicals which stimulate the growth of microorganisms. Phosphorus plays an important role in cell metabolism of both bacteria and fungi, being utilized in the form of phosphate salts or esters. Some specificity has been observed among various microorganisms in regard to the type of phosphate utilized, but, in the main, most phosphates are beneficial to growth. Also, phosphate esters enter into a wide variety of enzymatic reactions. Nitrogen-containing compounds provide an essential element which is used for functionl as well as structural purposes. Vincenzi (*2*), an early investigator, found that the cell wall of *Bacillus subtilis* contained 5 to 11% nitrogen. Mitchell and Moyle (*3*) found that the cell envelope composition of *Micrococcus pyogenes* was a glycerophospho-protein complex. Other paper mill chemicals that stimulate the growth of slime are ammonium salts, used as after-glow retardants in match board, and phosphate-type dispersants.

Some chemicals may cause chemical flocs or gels under certain pH conditions which create deposits similar in many respects to microbiological slimes. The two great contributors to chemical slime are alumina and silica. They not only are capable of forming a slime *per se* but they entrap hydrated fines, colloidal particles, clays, and silt. These formations also occlude many bacteria and fungi, resulting in complex slimes.

The use of moldy waste paper or pulp as part of the furnish frequently results in paperboard which has a musty odor. This type of waste definitely should be excluded from the furnish for food grades. If it is used for other grades, an additional amount of toxicant should be added to the beater or pulper.

Temperature is significantly related to the growth of slime-forming microorganisms. The optimum temperature range for most slime-forming microorganisms found in board mills is approximately 75 to 104°F. However, there are some thermophiles that will grow well at 130°F. or even higher. Fungi are sensitive to temperature and are not usually a problem above 120°F.

The pH is important to the growth of microorganisms. Although the optimum pH for growth of many microorganisms is about 7.0, there are other microorganisms which will tolerate more acid or alkaline conditions. The author has observed bacteria growing profusely in paper mill systems which varied from pH 4.0 to 10.5.

Our next important source of inoculum is the water supply. While water is an important raw material in the paperboard making process as a vehicle to transport, classify, and clean the fibers, it may also serve to transport inoculum into and throughout the mill, solubilize nutrients for assimilation, and provide the moisture needed by the microorganisms for the maintenance of their metabolism. Until recently, many board mills throughout the country used river or creek water which was not processed or treated to improve its quality from either a chemical or a microbiological standpoint. The use of raw water creates severe problems, such as increased slime, scale, and discoloration of the finished board. Fresh water should be treated adequately to control all slime-forming bacteria. It is recognized that this may require levels of chlorine which are higher than those normally used in the control of pathogenic types. As with all toxicants, bacteria vary in their resistance to chlorine. The nonspore-formers or vegetative types are readily killed by small doses of free chlorine under acid conditions; whereas, the spore-formers may require 10 to 1100 times as much chlorine, according to the work done by Tonney, Greer, and Liebig (*4*). Because the excessive use of chlorine is detrimental to the life of felts and does create corrosion problems, mill operators in increasing numbers are using other types of toxicants in order to achieve effective slime control.

While providing significant economic advantages by savings in water, heat, and chemicals and by reduction in effluent the re-use of white water in the board mill affords a greater opportunity for slime-formers to develop and flourish. The recirculation of white water frequently results in the buildup of nutrient materials and, subsequently, the build-up of slime. Thus, it becomes necessary to utilize more efficient toxicants so that all the benefits of a closed system can be realized. As is the case in many mills where a critical water shortage exists, white water is collected indiscriminately from many points and used for dilution or makeup. Highly contaminated white water from central collection sumps, stagnant machine pit water, or effluent settler tank water should not be used unless it can be treated adequately and economically to make it suitable for re-use. If this cannot be done, other water sources should be utilized.

Nearly all cylinder machine operators are familiar with slime, having been plagued at one time or another with gelatinous, slippery, or rubbery deposits in vats, flat screens, pipelines, etc. If these accretions are permitted to build up to the degree that they lose their attachment to surfaces, they will become part of the stock and eventually get into the sheet. Subsequently, as the sheet is calendered, the undispersed mass of fiber, debris, and gelatinous binder is squeezed out under pressure to form spots and holes, weakening the sheet to the point that it tears.

Although the physical appearance of slime deposits on the machine and in the sheet may alert the operator to the fact that microorganisms are not being controlled there are many direct manifestations of bacteria and fungi which often escape recognition. One of these which needs more recognition is felt plugging. Poor and uneven drainage of the wet felt has been related in some degree to the presence of microorganisms, according to investigators. Buckman (*5*) suggested that bacteria might play an important role in reducing the water-removal capacity of wet felts, observing that mills which maintained adequate slime control in the paper machine system achieved longer life and better performance from the felts. French (*6*) found that felts inoculated with bacteria would retain two to four times as much filler material as was retained by felts in which bacterial action was inhibited.

Drescher (*7*) found an iron bacterium known as *Sphaerotilus natans* to be a factor in the plugging of wet felts. This bacterium was isolated in 54% of the used felts obtained from 13 mills in nine states. Where microbiological plugging of felts is suspected, there is justification for the use of a suitable toxicant in the felt shower water or water supplied to felt conditioners as a supplement to the regular slime control program.

The problem of odor in paperboard is a most difficult one in many mills that manufacture board for food packaging. Since numerous factors can influence the odor characteristics of paperboard, it is almost impossible at times to trace the source and origin of the odor. Odors may result from the following:

1. Odoriferous chemical ingredients in the waste paper supply.
2. Moldy waste paper or pulp.
3. Inadequate microorganism control.
4. Poor cleanup.
5. Storage of board in a damp warehouse or in a warehouse taking in odor-contaminated air from a chemical plant, refinery, slaughterhouse, etc.

For the purpose of this paper, let us consider the possibilities of odor-producing microorganisms. Russell (*8*) has isolated six general types of odor from paperboard, and among them are at least three which might be the result of microbiological action. They are: sour, musty, and foul or putrid. Odor-forming bacteria and fungi are potentially present in all paperboard mill systems. This can be observed readily by smelling a sample of stock taken from the side of a vat, headbox, or chest which has not been cleaned for several days. As stock ages in a moist condition at machine room temperatures, there is a rapid growth of microorganisms. Solid or colloidal organic matter present in the mass is broken down into soluble compounds capable of being utilized by microorganisms. Enzymes which act outside the cell wall of the microorganisms bring about many oxidative and reductive changes in materials like proteins, carbohydrates, and fats. Some of the compounds thus produced may be highly malodorous. Among the more malodorous compounds formed from proteins are mercaptans, hydrogen sulfide, indol, skatol, and others. Carbohydrates are also changed to form odoriferous compounds. Fats, fatty acid derivatives, and vegetable drying oils present as contaminants or additives are potentially a source of rancid-type odors. The microorganisms associated with the process of decomposition may be obligate anaerobes, facultative anaerobes, or aerobes.

We have heard much about sulfate-reducing bacteria. These microorganisms are a significant factor in many board mills. They contribute to the development of odor and have the faculty of reducing the sulfates from alum and other sulfates to hydrogen sulfide. These bacteria require the complete absence of oxygen. Thus, they will be found in heavy layers of slime or stock deposits close to the surface interface of vats, pipes, and other surfaces where deposits collect and age. The microorganisms grow best at elevated temperatures and should be suspected wherever hydrogen sulfide is being evolved from water or stock containing sulfates but low in proteinaceous matter.

In addition to causing odors, sulfate-reducing bacteria are associated with the problem of corrosion. This was reported by Von Wolzogen Kuhr and van der Vlugt in 1934 (*9*), who observed that corrosion occurred in the absence of oxygen and that the hydrogen formed was utilized by the bacteria. Starkey (*10*) reported that, during anaerobic decomposition of organic materials, the hydrogen sulfide produced by sulfate reduction is released from the surface of the liquid and becomes adsorbed on the walls of pipes above the liquid. Eventually, the sulfide is oxidized to sulfuric acid by another sulfur-bacterium.

CLEANUP PROGRAM

The first expenditure for toxicant should be for the preparation of a toxicant-detergent solution to be used for the boiling out of the system at regularly scheduled intervals. This procedure is mandatory when a system is badly slimed in order to remove inoculum, sour stock, and debris which interfere with the effectiveness of the slime control treatment. Because the toxicant must come in contact with the slime-forming microorganisms, it is essential that all surfaces be cleaned to the metal, wood, or concrete base to prevent regrowth from within the slime film. Once a system has become covered with a heavy layer of slime, it is uneconomical to apply higher levels of toxicant. A boil-out is the only logical procedure to establish control in the shortest period of time. Many board mills boil out regularly as a means of insuring product quality and maximum production efficiency.

Mechanical cleaning of the system is greatly improved by employing auxiliary high-pressure pumps which are equipped with special attachments to direct the water in such a way as to facilitate the removal of deposits consisting of slime or scale. One example of special equipment which is effective is portable shower pipes with multiple nozzles which can be inserted into openings in vats and other equipment not easily or effectively cleaned by direct application of the hose.

An effective cleanup is an important part of good housekeeping and should be a standard production technique at every mill. For best results, trained crews that are thoroughly acquainted with the equipment being cleaned, adequate allocation of time for cleanup, and proper tools are required. Remember, a deposit which is not removed forms a base for regrowth and reinoculation.

The type of surface influences the degree to which slime may adhere. Rough surfaces, such as wood, concrete, or rusty iron, will permit attachment of fines, stock, and slime more readily than smooth surfaces. Old wooden surfaces should be faced with smooth, corrosion-resistant surfaces.

The careful use of toxicant sprays on wooden, concrete, and rough metal surfaces has been beneficial in controlling the growth of microbiological slime on such areas. The toxicant should be a penetrating type, preferably one that forms a slight film and is not completely washed away with the first application of water. After a contact time of about one to three hours, the toxicant may be washed away if early resumption of operations is necessary. Longer contact times are valuable. Some benefits can be obtained by filling the vat with water and toxicant and allowing the solution to soak if shutdown is prolonged and spraying is not feasible.

Pits, sumps, and settlers should be emptied, hosed thoroughly, and then sanitized with a toxicant solution. A 100-gal. tank, fitted with a pump and hose, can be used to apply a very dilute toxicant solution to those areas where a portable garden-type sprayer cannot reach.

Wet felts should be preserved during a shutdown. One useful procedure is to wash the felts with a suitable detergent followed by a rinse with water to remove the detergent prior to the application of the preservative. Wet felts so treated will be soft and more easily wetted for quicker startups.

Slush stock to be held over should be treated with a toxicant to prevent the development of disagreeable odors resulting from the growth of bacteria and molds. Slush stock allowed to "sour" may not only become a source of odor in the board, it may actually change the drainage rate to what is commonly called "slower" stock. Work on paperboard by Rudolfs and Nemerow (*11*) demonstrated that the freeness of paperboard stock can be influenced to a significant degree under conditions conducive to the growth of microorganisms.

DAILY MICROORGANISM CONTROL PROGRAM

The daily slime control program should be designed to provide effective control throughout the entire system. There is no specific point of addition that is common to all mill systems because each system is different. Machines in the same mill may vary in their tendency toward slime development. Each system should be studied carefully to determine the best points of addition, the effect of dilution

on the toxicant level, points of maximum contamination, and the contact time during which the toxicant is expected to function best. The contact time for various toxicants varies with the chemistry of the compound. Some toxicants function by killing the microorganism by reaction with the cell membrane and effecting a quick kill; other toxicants may inhibit cell metabolism by interfering with the functioning of enzymes, thus starving the cell. Minimum contact time may vary from 1 hr. a day to a continuous feed, depending on the toxicant. After a treatment program has been established, a close follow-up is necessary to see that the expected benefits are achieved. This may require adjustment in treatment levels or location or a change in toxicant.

It is essential that one man from the mill staff be assigned the duty of seeing that their own slime control program is carried out. Lack of assignment, or division of responsibility, results in inefficient treatment, either in feeding excessive amounts or in feeding insufficient levels of toxicants for correct periods.

The question usually arises as to the cost of an effective slime control program. The answer to this question lies in the knowledge of the magnitude of the losses, either actual or potential. In planning a program, the desired expenditure should be based on a complete microbiological and physical plant survey so that relationships between cost and losses may be determined. We have outlined the five major categories of losses earlier in the paper, and these should provide a basis for estimating the total loss. Stitt (*1*), in a detailed study of losses and methods of evaluation, reported that losses may vary from $1.00 to $6.00 per ton when slime is not controlled. Lack of recognition of losses has resulted in many operators' being content with an inadequate slime control program. A sound rule to apply in relation to cost is to increase expenditures for slime control to the point of diminishing returns. That is the point where the maximum net savings are realized over and above the cost of the slime control program.

All programs should have a factor of safety to insure adequate treatment. The concept of using a factor of safety is sound engineering practice, even when materials of known strength are used under conditions of known stress. In the author's opinion, it is even more necessary when dealing with microorganisms in a changing environment, such as a paper machine, to incorporate a factor of safety into any slime control program.

SUMMARY

Most paperboard mills provide an environment which has all the necessary prerequisites for the entrance of microorganisms and their sustained growth, once in the mill system. Many of the factors influencing microbiological growth are fixed by the nature of the raw materials used. The requirements for effective control of microorganisms are most critical in a paperboard mill because of the variety of microorganisms which enter the machine system and the complexity of the equipment and processes.

Effective microorganism control results from a recognition and comprehension of all the factors which influence growth. The use of toxicants is only part of general good housekeeping practices. Maximum benefits are achieved when the proper application of microbiological techniques is combined with thorough and methodical housekeeping.

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Chemical Cleaning Procedures in the Paperboard Industry

ROBERT KIPP

Our purpose is not only to describe accepted procedures, but also to offer suggestions on steps that lead to the selection of efficient cleaning procedures.

During the nearly half century of TAPPI's existence, many changes have taken place in your industry. The same is true of ours. Keeping pace with your progressive industry has caused ours to develop materials, methods, and equipment that are economically acceptable. This takes costly research.

Our present research is geared to continue keeping pace, and with good reason. Reliable sources tell us that demand for paperboard should rise 2% in 1960, giving a total annual output near 15 million tons of paperboard. Long term forecasts indicate that the total paperboard demand will reach 20.1 million tons by 1965—26% above the demand in 1960.

This means that extra demands will be placed on you and your operating personnel to keep your equipment producing the paperboard needed to satisfy the tonnage requirements seen by the forecasters. To relate this more closely to the discussion, it means that efficient maintenance cleaning procedures are necessary if your machines are to continue producing high quality products with minimum shutdowns.

The chemical cleaning materials, equipment, and procedures to be discussed now were developed over a long period of time. Nobody invented or consciously proposed their development. They were brought to their present state through chemical and engineering research, through trial and error, if you will, and through plain hard work. These materials, equipment, and methods were born out of your needs. Take, for example, the all important maintenance procedure of . . .

CLEANING STOCK PREPARATION SYSTEMS

There was a time when most of this work was done manually, using simple cleaning agents or none at all. Today, compounded, specially designed chemical cleaning solutions do the job of dissolving the soils and/or breaking the hold of the bonding agent.

The build-up of pulp, slime, dirt, and furnish residue in stock preparation units is one of the biggest problems in paperboard mills. Unless these residues are removed in regular washup, they can break loose, and cause trouble on the paperboard machine. They clog the wires of cylinder molds, plug up suction areas, and mat up felt fibers. In extreme conditions, they can cause paperboard spoilage and costly down time.

Generally speaking, the entire stock preparation system area is cleaned at the same time. Solutions are usually made up in the hydrapulper or beaters, and circulated by gravity or by process pumps through the stock chests, the deaerators, thickeners, screens and clarifying units, as well as through the refining sections, up to and including the machine chests. The purpose here is to clean all areas at the same time, and to get the most efficient and economical use from a sizable volume of cleaning solution. Chemical cleaning materials used to make up the solution must work fast, often at ambient temperatures, and be safe on all the metals and materials involved, as well as inhibited against foaming excessively.

Robert Kipp, Oakite Products, Inc., New York, N. Y.

CYLINDER AND VAT MAINTENANCE

Cleaning the cylinders and vats is also an important and recurring maintenance procedure. There are three basic ways in which this job is accomplished. In the first method, the chemical cleaning solution is made up in the vat and the cylinder is rotated in the solution, which is made up to a depth that will cover the bottom portion of the cylinder. Often this procedure can be speeded up with the use of a steam detergent unit which pulls the solution from the vat, and applies it under pressure over the face of the roll as it turns.

A second procedure is to apply the chemical cleaning solution to the shower spray by pumping the cleaning solution through the water shower line, after making proper piping adjustments. A return line is taken from the cylinder vat to carry the solution to a supply tank. From this point, it is recirculated by a pump through the shower spray.

The third procedure is to make up the chemical cleaning solution in the machine's pulp supply chest, and use the process pump to move the solution from the chest into the vats with the machine running. In this way, all surfaces usually contacted by the pulp are equally contacted by the chemical cleaning solution. This method can be varied to include felt washing. The felts are left on the machine with the tension on during the cleaning operation, so that the solution can be transferred from the cylinder face to the felt. This way the felt is cleaned, as well as other surfaces, including the press rolls. Complete rinsing with clear water follows each of the above operations.

FELT WASHING

One of the most important cleaning procedures on the cylinder paperboard machine is felt washing. While there is a wide variety of compounded cleaners to use, depending on the type of soil in the felt, the following methods are generally accepted to be the most efficient.

The first is a method of washing the felts on the machines during a shutdown by applying the chemical cleaning solution through a manually operated spray unit, or with a shower spray reaching the width of the felt. Tension is off of the felt. After the chemical cleaning solution has been applied, and allowed to soak, the tension is again returned in order to squeeze the cleaning solution out of the felt.

A variation of this shutdown method is to spray the chemical cleaning solution on the felt through a shower pipe, or with a sprayer, removing the solution through the suction press rolls. Some mills have installed this method to clean both the felts and the roll at the same time.

Another widely accepted method of washing felts on the machine is the procedure of washing them "on the fly" while the machine is making paperboard. The chemical cleaning solution is applied at a point where the paperboard leaves the felt. This is followed by a shower spray rinse and a suction box (either permanent or traveling type) installed in a position to remove the cleaning solution residue and the soil before the felt returns to pick up the paperboard.

In slower operating machines, where felt life is not excessively shortened by mechanical strain, the felts generally last a longer time. When this is a fact, some plants remove the felt from the machine for washing in a textile-type washer. The choice of a chemical cleaning solution here again relates to the type of soil being removed and safety factors.

SUCTION PRESS ROLL MAINTENANCE CLEANING

One of the most critical areas on the paperboard machine where maintenance cleaning plays an important part is in the suction press roll. Regular maintenance with chemical cleaning solutions can help to solve the problem, and keep the rolls in production for a longer period of time. The use of properly compounded chemical cleaning solutions for the maintenance of suction press rolls has gone a long way in eliminating the tedious job of using power tools to drill out the holes manually.

One method often used for chemically cleaning suction press rolls is performed off of the machines. The chemical cleaning solution is made up in a vat in a central cleaning area, usually in the machine shop. The solution is made to a depth sufficient to cover the bottom of the roll as it is rotated through the solution.

Such a cleaning vat is fitted with side journal braces to support the roll, so that it can be turned easily in the chemical cleaning solution at regular intervals.

The most important development in this particular maintenance cleaning operation is in the application of the cleaning solution inside the suction press roll, while it is in place on the machine. This work is done during the shutdown by connecting into the line supplying the inner water shower with a replacement line carrying a chemical cleaning solution. This solution is pumped from a separate solution tank through the inner shower of the roll, and is recovered in a trough under the roll. From there it is returned to the solution tank. A motor and pump is used to circulate this solution, until cleaning is completed

A relatively new method which is recommended to certain mills, where equipment and the type of paperboard being produced permits, is to clean suction press rolls "on the fly." In this procedure, a proportioning pump is used to inject a chemical cleaning solution into water supplying the inner shower spray of the suction press roll. The point of application is adjusted so that the vacuum will be able to remove the chemical cleaning solution residue and the soil before it runs out through the roll. This procedure is designed to prevent soil from setting up and adhering tenaciously to the inner surface and holes in the roll, and to eliminate shutdowns for roll cleaning.

CLEANING DRIER ROLLS

The major cleaning operation in the drying area is on the outer face of the drying rolls. Here, any deposits which settle out of the paper are "set up" on the roll face by the heat of the roll. Ordinarily, certain rolls are more subject to soil build-up than others. In this cleaning procedure an individual roll is sprayed with a compounded chemical cleaning solvent, under pressure, as the roll turns. The doctor blades are placed down in position to remove the residue loosened by the cleaning solution.

If the drier felt is to be cut away and replaced during a machine shutdown, it can be used to good advantage, before replacement, in cleaning roll surfaces where a large number of rolls are to be cleaned. The chemical cleaning solution is sprayed on the felt at a given point, and it carries the chemical cleaning solution to all of the roll exterior surfaces to loosen the soils. Doctor blades are brought into position, or high pressure air blow-off follows, to remove loosened soils.

CONCLUSION

We have described and illustrated some of the standard procedures that are today being used in the paperboard industry for major maintenance cleaning jobs. There are many more, including the maintenance cleaning of the back side of the drying area, the maintenance cleaning of hoods over the drier rolls, and related maintenance jobs on the cylinder machine exterior.

What is to be learned from this presentation of procedures? Simply that a good deal of thought should go into the selection of the proper chemical cleaning compound and the proper cleaning procedures for your particular mill. All of the pertinent facts should be brought to light to determine the most efficient answer for you.

These facts can be determined in many ways. One way is to follow a step-by-step investigation. You might well call it a check list that includes a consideration of the factors

surrounding the cleaning problem, a study of the factors involved in the application, a selection of the proper chemical cleaning solution, and a method of applying the solution efficiently. To sum it up: consider, study, select, apply. Let's call it the CSSA formula, and take a look at this slide for details. As you see, you first consider the following:

1. The surface to be cleaned.
2. Dirt to be removed.
3. Degree of cleanliness required.
4. Quality of the water supply.
5. Cost of the complete cleaning operation.
6. Safety to operators and parts being cleaned.
7. Method of application.
8. Disposal of the spent cleaning solution.

Next you study these factors:

1. Concentration.
2. Temperature.
3. Agitation (of the part being cleaned or the solution).
4. Age and degree of contamination.
5. Time of application.
6. Rinsing facilities.

Then you select a chemical cleaning solution. Generally speaking, there are four categories:

1. Alkaline type.
2. Solvent type.
3. Acidic, and
4. Combinations of the above.

When all of the above factors have been considered, then the choice of the method of application must be made. Of all of the methods presently in use in the paperboard industry, you will recognize the circulation and spray-wash methods as being the most widely used. Here are the general classifications of methods of application:

1. Immersion (still, agitation, electrolytic, ultrasonic).
2. Circulation.
3. Spray (washing machine, air pressure).
4. Steam cleaning (high pressure).
5. Barrel method (rotation).

Whether you use the CSSA formula or any formula of your own, the facts developed are not alone the answer to your problem. They would be like the pieces of a giant jigsaw puzzle dumped on a table. When so placed, the pieces do not give a true picture. Helping you fit them together so that they do make a picture is the inescapable job of the men in our industry.

Like all analogies, the comparison of facts and jigsaw puzzles breaks down. When you are face to face with the very real problem of maintenance cleaning, there is not one picture, and one picture only, that can be achieved, as there is in every jigsaw puzzle. In practical application, there can be several different pictures formed from the fact developed by such an investigation.

The picture developed from facts in your mill must fit the requirements of your production and maintenance schedule. We believe that informed interpretation of the facts is what you can use. The technical service men in our industry provide it. So, cooperation between our industries is vital. Look what it has done so far. Who knows what the man addressing himself to this subject will have to say 10 or 20 years from now. We think, it will be beneficial, as we hope this has been.

Whys and Hows of Cleaning in Board Mills

DONALD F. LEHMAN

UTOPIA for the filler and liner systems of board mills is on the horizon. It is not here today because nobody can write a set of rules which universally applies to stock preparation systems for waste paper. Unfortunately, the wide variations in the grades of furnish and in the end products make one set of rules impossible. However, full knowledge and application of the basic principles of pulping, defibering, centrifugal cleaning, and screening bring Utopia nearer for board mills.

DONALD F. LEHMAN, Engineer, Screening, The Black-Clawson Co., Shartle Div., Middletown, Ohio.

WHYS OF CLEANING

There are many improvements which can be accomplished with cleaning equipment, such as improved production and quality, up-grading furnish, protection to subsequent equipment, less down time for washups, and fewer machine breaks. If we study each of these in more detail we can see how it can be economically practical to add new pulping and cleaning equipment or possibly wholly new systems to achieve a certain goal.

A certain amount of cleaning must be done to use wastepaper and meet standards of cleanliness for any given grade of board. In some cases, however, the cleaning system dictates the limitations of the grades produced. Just how far a mill will go in the direction of a complete cleaning system may be dictated by sales potential and policies. Product quality and available cleaning equipment can usually be made compatible by strict scheduling of high grade board immediately after a washup and the use of high cost, clean furnish in the beater room. There are many times, however, when even these precautions are not sufficient if the materials used in the furnish contain certain contaminants which are unsuspected. Contaminants such as plastics or tars especially in liners, greatly downgrade a finished product, resulting in losses which equal the cost to install modern machine screens that can eliminate such contaminants.

One of the most promising whys of cleaning being studied today is that of upgrading furnishes, that is, the use of lower grades of wastepaper to make high-grade board. This principle is particularly applicable to filler systems but can also be applied to many liner systems. As an example, a high premium is paid for high-grade furnish in order to obtain well sorted material containing a minimum of foreign matter. Even though there may be no particular need for the strength characteristics in the high-grade furnish, cleanliness demands that particular furnish at high cost. Unless the papermaker is presently using 100% of the cheapest wastepaper on the market, savings of $2.00 to $5.00 per ton can be made by upgrading furnish with a revised cleaning system. The cheaper furnish will ultimately be cleaner and more desirable than the more expensive furnish used with an inadequate cleaning system.

Many times a mill having no trouble at all from the standpoint of dirt in the sheet, is plagued by high wear in jordan or refiner fillings. This same mill will complain of short cylinder wire life, dirty drier rolls, short felt life, or marked calender rolls. Utopia for this mill may be the addition of only a single item of cleaning equipment at the proper place in the system. Whatever the solution, it is usually cheaper to add cleaning equipment in the system than to continue paying for the damage of the dirt or buying a higher price furnish. Full mill washups are expensive. The period of time between washups can be increased if the objectionable material which builds up in a system is caught and rejected. A cleaner system would also permit mills to take rush orders for higher grade board late in the week which they normally would have to turn down. The actual down time for washup periods also can be greatly reduced when the proper equipment is used and the system dirt is reduced.

Another expensive item which can be traced many times to dirt in the system is breaks on the machine. This is particularly true in mills where high quality is not required and consequently very little cleaning equipment is used. Many mills of this type have gone for years living with this

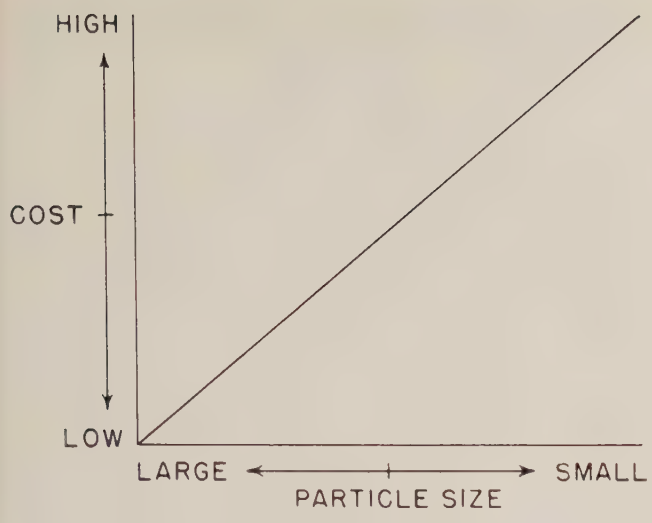

Fig. 1

condition when a relatively simple installation of cleaning equipment would virtually eliminate this annoyance and expense.

There are undoubtedly other reasons why cleaning equipment could and should be used, but those mentioned should suffice to point out the important contribution of the selection and use of proper equipment in the economics of board production.

HOWS OF CLEANING

In a board mill there are two areas of cleaning. These are in the beater room and at the paper machine. How much cleaning equipment will be used in each area and which items of equipment will be used will be dictated by any one of the foregoing reasons or a combination of them.

Cleaning is the separation and removal of foreign matter from the papermaking fibers and there are only two basic cleaning principles which separate and remove foreign particles. These are separation by particle size and separation by weight. There are many variations of equipment and procedures for the application of these principles and many combinations may be required to do a satisfactory job. The end result desired in terms of product quality will dictate the choice and location of equipment used in a wastepaper stock preparation system.

Particle size and cost of removal are prime consideration to determine what cleaning equipment is used and where in a system such machinery should be placed. Figure 1 shows graphically how costs go up as particle size goes down. Therefore, it can be seen that it is more efficient and much cheaper to remove a piece of rag from a pulper than several pieces of string at the paper machine. It is also much easier and cheaper to remove a nut or bolt from the system than a grain of sand. Consequently, the maximum amount of foreign material at maximum particle size, should be removed in the early stages of a wastepaper stock preparation system for optimum performance.

BEATER ROOM CLEANING

Operating conditions in the beater room must be kept within the proper range for best efficiency. More specifically, if consistency and flow rates are not controlled within reasonable limits, cleaning efficiency will suffer seriously.

Manual control of consistency in pulping and cleaning operation can vary within wide limits and for this reason automatic consistency control is very desirable in the pulper or immediately thereafter and before the stock gets through cleaning equipment. In several instances, mills have suffered for lack of thickener capacity which forces them to operate at too high a consistency in order to keep up with machine production. Thickeners should be installed to handle not just the normal continuous put-through rates but should also handle the maximum rates encountered due to peak demands from the machine. Since cleaning equipment is designed for a definite put-through rate, it should be operated in its specified range.

Centrifugal cleaning equipment performs efficiently in the controlled range of 0.8 to 1.0% consistency. Of course there may be specific jobs such as nut and bolt removal which could be done at higher consistency, but even this is done more positively at lower consistencies. Consistency control, however, too often is subject to operator error and inadequate thickener capacity.

Centrifugal cleaners are designed to handle a definite number of gallons per minute with a given pressure drop. Enough units should be installed to handle the maximum flow, and if there are to be variations in the flow, provisions should be made to recirculate when less than full flow is needed. If this is not done, the pressure drop will be reduced and cleaning efficiency will suffer. Centrifugal cleaning is normally the first stage of cleaning following the pulper. This avoids a build-up of solids in pipelines and protects screens from damage. Screen performance is not greatly affected by reduced flow rates normally encountered. It is, however, most important that enough screens be installed to handle the maximum production since screening efficiency can be greatly reduced if the equipment is overloaded.

There are several ways in which cleaning equipment can be made most effective. One of these is to remove as much of the foreign matter as possible in the pulping unit which is also the first stage of cleaning. Several mills are using $^1/_4$-in. diam. holes in the extraction plates of the pulper in continuous systems as compared to the large majority of $^3/_8$-in. diam. holes being used. The smaller holes produce much cleaner stock and the subsequent cleaning equipment performs more efficiently with a lower percentage of reject material to handle.

One of the most important steps which greatly aids cleaning efficiency in the beater room is a high degree of defibering. In a system where the treatment of small pieces of undefibered paper may be necessary, a secondary defibering unit may be added to complete this job immediately following the pulper. This unit should be one which will not mechanically treat foreign materials but will rather defiber the softened particles of paper stock passing through it. Better defibering permits the removal of more of the small heavy particles in the centrifugal cleaners and also increases screen capacity by reducing hole blinding caused by undefibered wastepaper. Finally, more complete defibering reduces jordan horsepower requirements and increases Jordan filling life.

Primary screening in the pulper may be followed by one or more stages of finer screening operation for economical and efficient production of a cleaning system. The cleaning efficiency of any screen is greatly increased by operation with continuous reject removal. Practical limits of reject removal are 10 to 15% of the flow coming to the screens. With pressure screens, the foreign material being rejected will be conveyed by a flow of stock and water which must be reclaimed and returned to the system ahead of the primary cleaners. It is practical in the beater room to employ a dry reject type screen to clarify the rejects and return the accepted stock to the pulper.

Most beater room cleaning systems in board mills today can be classed as coarse screening systems. There is still a considerable amount of dirt which can and does go through these systems into the refining equipment and on to the paper machine. Much of this dirt can be caught by cleaning equipment at the machine, however, due to the small particle size some of it still goes through to the sheet. By the addition of another stage of finer screens in the beater room,

much of the trouble from this dirt can be eliminated and the use of cheaper grades of furnish is made practical.

Practically all of the liner systems today are operated on a batch basis whereupon the furnish is pulped at consistencies as high as 6%. Except for the extractor plates in the pulpers, there is no chance to effectively clean this stock when certain contaminants are encountered or the pulping unit is used on low grade furnishes to meet production requirements. The end result is rapid wear in refiners if the contaminant is small metal particles or a tear-up of refiners if it is large particles. It may also cause plugging of machine screens and the passage of considerable dirt to the sheet. Continuous pulping with a system of cleaning equipment could well be the answer to many of these problems. Depending upon the production needed, a solution might be to provide a screen or centrifugal cleaner, or both, along with a thickener, to handle the grades for which the use of dirty mixed waste furnish is desired in the liners. There are many mills today giving favorable consideration to changing from batch liner operation to continuous operation with a cleaning system for such reasons as these and also to enable them to use lower grades of wastepaper furnish for many grades of production.

PAPER MACHINE CLEANING

Paper machine screens serve a twofold purpose. They protect the machine and the sheet from contamination from such materials as dirt from chests, dirt which escapes the beater room system, pipe scale, deteriorated equipment, dirty broke, slime slugs, felt strings, and stock lumps. They also aid in the formation of the sheet.

In order to do these jobs well, the screens should be capable of screening all of the stock and water going to a single vat and reject all unwanted materials. When a screen is used to screen only the stock being fed to the machine, it is in reality a secondary beater room screen located close to the machine. Since dirt at this point is greatly reduced in particle size, the screen does not operate as efficiently as it would in the beater room and cannot perform the function as an aid to formation.

Centrifugal cleaners operating at the paper machine are usually of the high pressure differential type because most of the material to be removed is very small in particle size. Use is determined by the need to remove sand and grit which cannot be effectively removed in the beater room.

Since most of this gritlike material is contained in the new stock coming to the machine, it may not be necessary to clean all of the water going to the vat. The 250 to 500-g.p.m. centrifugal cleaning units are normally sufficient to handle the stock for any vat at a consistency less than 0.8% and in this manner considerable horsepower savings can be realized.

The cleaned stock is picked up by a second pump where it is mixed with proper amounts of white water for required vat consistencies and passed through the screens on the way to the vat.

CONCLUSION

Machinery, equipment and processing methods, provide the papermaker with many opportunities for cost reduction in basic raw material values. The key to realization of these savings lies in the understanding and application of certain basic fundamentals of stock preparation engineering. The principal factors are:

1. Complete fiber separation without loss of strength.
2. Foreign material removal without reduction of particle size.
3. Use of specific gravity differentials and centrifugal forces for separation of foreign materials.
4. Use of particle size differential to separate paper fibers from nonpapermaking materials.
5. Design and application of machinery to perform specific functions to attain specific goals in papermaking products.

Rubber-Covered Rolls for Cylinder Paper Machines

JOHN J. CONNORS

I AM most grateful for the opportunity to discuss, this afternoon, rubber-covered rolls used in connection with cylinder machines. The function or work required of a pair of rubber rolls on a paper machine varies from the wet end to the dry end. To simply remove water at the highest rate possible is not the only requirement of rubber-covered rolls. Steel cores could accomplish this, but unfortunately this would bring about other undesirable conditions. Therefore, rubber becomes an ideal material to be used as roll covering in the interest of good felt life and proper sheet formation.

RUBBER

Rubber has very desirable properties for the papermaker as it can be produced in various hardnesses and thicknesses, resulting in the proper cushioning effect wherever necessary, as well as being well suited to compounding in very hard ranges to provide almost metallike surfaces. Today the rubber industry compounds rubber to offer roll coverings with special desirable characteristics for any given installation. The art of compounding rubber is comparable in many ways to the art of papermaking. Every day rubber processing becomes more and more of a science requiring large amounts of technical data to control the reactions of rubber under various pressures at given speeds, diameters, thicknesses, and hardnesses.

Many new synthetic polymers as well as other ingredients are used today which makes it difficult to classify a rubber covering simply by referring to it as a rubber roll. I am sure we all realize that natural latex sap, which comes from the rubber tree, does not necessarily make the best roll covering. Therefore, synthetic rubbers have found their rightful place in the papermaking process where high temperatures, corrosive conditions, or excessive wearing problems prevail, where natural crude coverings would not perform as well.

THE NIP

The use of the term "what is your nip width measurement" is becoming as common as "what is your crown." I believe this is rightfully so, as after all, what takes place in the nip has a direct relationship to the performance of a pair of roll coverings. In other words, the nip is the business area of a pair of rubber rolls. Some of the elements involved depend on the loading, temperature, diameter, cover thickness, and its hardness. When time is taken to study the requirements, or work, a pair of coverings are to perform, then the nip width measurement becomes an important factor. With today's modern paper machines utilizing faster speeds, wider dimensions, the uniform nip and its measurement begin to show its real importance. Pressure in the nip has a bearing on extraction, felt life, formation, and cover life. Our research people have been working to supply this technical data concerning nip widths. With this in mind, we have built a test machine to study the effect of rubber hardnesses, rubber thicknesses, and roll diameters on nip widths.

The equipment tests rolls ranging from 12 to 36 in. diam., 12-in. face, and loadings can be varied from 0 to approximately 1500 lb. per lineal in. This machine can be operated at speeds up to 2700 f.p.m. This work, which is still in progress, has given us a clearer understanding of the business end of a pair of rolls which will eventually be of great practical service to the paper industry.

Our goal has been set at working out a mathematical relationship between the nip pressure, hardnesses, thicknesses,

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and roll diameters. With this mathematical relationship the paper mills will be in a better position to foretell what can be expected when changes in thickness or hardness are contemplated on a pair of press rolls.

PRESS ROLLS

Today, the mill superintendent has a rather large list of available coverings to consider when the sheet comes in direct contact with the top engaging roll. However, the deciding factors in selecting the proper covering have not recently changed to any great degree. Water removal, and proper release characteristics to prevent picking and sticking, are important requirements, as well as resulting in normal regrindings for overall life of the covering. With these objectives in mind, the rubber industry has made great strides in producing top press rolls with varying degrees of surface conditions which aid in proper release. Today, there is still no universal top press roll which operates successfully on all grades of paper. But, with a better understanding of the problems posed by various paper grades, roll covering performance is constantly improving.

The use of rubber-covered suction press rolls either as bottom rolls or top rolls, if you are speaking of an invert press, has allowed a wider range of hardnesses for top press rolls. With the aid of suction, softer top press rolls have been utilized where their characteristics aid in the formation of the sheet. It should be remembered, however, that the hardness of the drilled suction roll, regardless of its actual plastometer reading, will act softer under loads than its actual plastometer reading would indicate. For this reason one should consider carefully the proper hardness on a suction roll covering to resist corrugating or distortion of the holes under heavy pressures. The overall life of bare presses or suction press roll coverings can be greatly increased by following some basic rules for good roll performance.

Load the covering only to accomplish what is required, as additional loading reaches the point of diminishing returns very quickly and results in poor life of the felts, as well as the covering, without additional water removal. If at all possible, take nip width carbon impressions of your press suctions to assure yourselves that proper crowns are being utilized. Incorrect crowning will create excessive localized pressures which will wear unevenly and cause excessive removal of rubber during regrindings. Changes made in felt or other cleaning solutions should be checked carefully with your roll supplier to prevent softening or swelling of the covering which causes needless wear.

I think it is also timely to examine the industry tolerances on rubber rolls. Experience has shown that in many cases where hardness requirements are closer than the ± 5 on the Pusey & Jones plastometer, the reasons for such requests many times are not justly founded.

Further thought should be given to determine the real problem, which is the nip or the business end of the roll as previously stated. Such questions as the cover thickness, core construction, changing of speeds and temperatures, could conceivably have a greater effect than 5 points on a plastometer gage. We must not underestimate the importance of the proper hardness, but it is wiser to show the effect of hardness in its proper perspective, based on facts. Obviously with every change in cover thickness there is a change in the nip contact with comparable loads. Small diameter rolls with thin rubber coverings result in harsh nips which in themselves can be desirable or undesirable. Whenever possible, sound reasoning should accompany requests or specifications which are closer than the accepted industry tolerances.

CARE AND MAINTENANCE

This subject is one that will be with us forever. Therefore, it is worthy of repeating. Roll manufacturers and other allied suppliers usually furnish some type of record book or performance data sheet in order to accumulate on the performance of their products. These records can also serve as a good guide to help establish a worth-while maintenance program for reservicing or regrinding of roll coverings. Such a program generally results in closer inspection of roll coverings to keep them in good operating condition. To help reduce costly downtime, do not overlook the importance of having a roll case designed, allowing sufficient room to prevent the covering from coming in contact with any object. Never use metal chains, or cables on either the rubber covering or in the bearing area, when changing rolls. Wide, rubber-covered belt slings are quite commonly used today when removing or installing press rolls. When rolls are received and inspected, be sure that the paper wrapping is replaced and that the roll is stored in a dark, cool place, and if at all possible, in its original case. If a rubber covering is subjected to freezing temperatures before it is used, have it installed in the machine room or in warmer temperatures to allow the covering to return to its normal hardness and temperature slowly. Whenever possible, a roll held in storage for a long period of time should be resurfaced to resist checking or cracking due to surface oxidation. A sufficient number of spares is the most effective way to capitalize as a proper maintenance program. Prevent rubber rolls from developing a wet or flat spot by insisting that rolls be disengaged when the machine is down. Most mills have a regular lubrication program to reduce overheating of bearings and thus eliminate premature-cover failure at the ends of the roll. Even with the development of new materials for use as roll coverings, proper maintenance program must continue to share the limelight if top quality performance and best overall economy are to be achieved.

Cylinder Board Discussion

The cylinder board discussion held during the 45th Annual Meeting of the Technical Association of the Pulp and Paper Industry, convened in the West Ball Room, C. D. Coffman, of Chesapeake Paper Co., presiding.

Chairman Coffman. To me this is the important part of any meeting. Five papers were presented. They are certain people's ideas, but I know we don't all agree with them, and this is the time to set our thinking straight. So with that I would like to have questions now from the floor on any of these papers that were given.

O. P. Fussell (Columbia Box). Vic, this 317-L—apparently you have got something better than 316 stainless for the cover wires.

DeForest Victor Vigeron (W. S. Tyler Co.): Well, 317-L is used only for higher temperature welding. Most welding, I believe, or the earliest welding of stainless steel wires, was with silver solder, but now there is in use a gold-base solder commonly known in the industry as Permabrace which is made in several numbers. 317-L is the same as 316, except it's a lower carbon, and it is much better than the higher temperatures. Does that answer your question?

Mr. Fussell: No, it doesn't. Some of the people that cover for us might want to comment on that.

Mr. William B. Hogg (Hayden Wire Works): Well, I think Vic has just about brought it out. In the welding of stainless steel the big factor has been to get a low carbon content, and this you do get in the type 317. It is particularly low in carbon content, and, using high heat on braided wires has always left carbon precipitation directly in back of the weld. Now, when you go to the 317, which is extra low carbon stainless steel, you eliminate this carbon precipitation.

Mr. Vigneron: There is, however a distinction between the 317 and the 317-L. If you want the low carbon, it must be specified as 317-L—"L" standing for "low carbon."

Mr. Fussell: I think most of us who use plain extractors with the two faces sometimes will have a great deal of trouble

holding the wires on, and most of us have settled with 316. Maybe we will get some help with 317-L.

Mr. Vigneron: 317-L is not yet available in all of the specifications. We are weaving it. As soon as we have a quantity justifying the setup of a loom—and we soon will—we can meet most of the specifications. Extractor 22 × 24 is not yet available in 317-L.

Mr. Fussell: No, I'm not talking about 22 × 24. I wouldn't be standing up here if it was that. It's where we have the two faces and the fine wire on the top. That's where the trouble comes in.

Chairman Coffman: O. P., are you using a welded seam? You are using stainless?

Mr. Fussell; Yes, and it varies all over the lot.

Chairman Coffman: That's what I was going to ask you. Do you have any experience, or would you care to tell what your experience has been on life? How long have you been doing this?

Francis M. Myers (Columbia Box Board Mills): I think a year and six months is the longest we have had, and I daresay 20 hr. is the shortest.

Mr. Fussell: That's what we are up against.

Mr. Vigneron: With that silver solder or Permabrace?

Mr. Fussell: It's 316, I'm sure, that silver solder.

Mr. Vigneron: I think you will do well eventually to wind up with 317-L, when it becomes available.

Mr. Hogg: We have had extractor rolls in operation better than 2 years in various mills, and they are still running. I'd just like to bring that up; and O. P. has brought up the fact that he had got a year and six months, and he's got a double cover. These are double cover. That is a special alloy that we use.

Chairman Coffman: When you speak of a special alloy, that is the alloy that you use to solder with, not the face itself?

Mr. Hogg: That's right.

Chairman Coffman: The face is just ordinary stainless steel face?

Mr. Hogg: We try to get it extra low carbon. We insist on that, if possible. Where we can, we use extra low carbon stainless steel, and we have found that it is very successful throughout the trade.

Mr. Vigneron: It's because of the higher temperature you have to use.

Mr. Hogg: Will you bring out the fact that if you are getting low life on your wire, and so forth, or your wires are slipping, you have to take into consideration the fact that you may be a lot heavier than you should be, and so forth. You can weigh one side heavier than the other and pull the cover right off. That has been done in 2 min. That can be verified throughout the paper trade.

Mr. Vigneron: I think while we're on this subject of 316 and 317 it would interest you to know the difference in composition of the two metals. The 316 is 16 to 18% chrome, 10 to 14% nickel, and 2 to 3% molybdenum. The 317 is 17 to 20% chrome—higher in chrome—but the same in nickel, 10 to 14%, and the molybdenum is 3 to 4%. Those are all qualities that you need for these chlorine jobs where you have that trouble.

Chairman Coffman: Vic, have you had enough experience on this 317 yet to know that you have the right metal in it? The life is just as good as your 316?

Mr. Vigneron: Yes. We have had a lot of experience, but we still have some indications of the chlorine attacking the stainless steel even on 317, and I think that it's the entrainment of this chlorine between the knuckles of the wire. If it were only possible to clean them and rinse them thoroughly to get that material out of the knuckle in the wire, corrosion of the wire wouldn't take place.

Mr. Fussell: Would any of you wire people like to comment on what backer you should use against a 40 or 50-mesh? It's a rough surface. If we didn't have printing requirements, we would never put that top face on.

Mr. Vigneron: I would like to have a 14-mesh backing on it. There is no real rule on it.

Mr. Fussell: Would the 14 be too rough?

Mr. Vigneron: No, it would be a smoother surface than one that is coarser than that. The knuckles of the backing wire will wear if your facing wire isn't tight. You have to work out a backing with a certain face that will give you the best drainage consistent with a decent life.

Mr. Fussell: Of course, you get yout best drainage with a 22–24, but you get in printing troubles there. It won't print.

Mr. Hogg: On 22–24 the main reason it's not used is the pressure supplied to the extractor itself. On the 14, if you applied a 14 or anything less than that, the pressure on your extractor roll would push these bottom knuckles right through your 40 or 50 face, if you had it. That's one reason why 22–24 flat warp is widely used as an extractor roll. If it comes to where you have to rip the face off during a run, why, you rip it off and start right up and get along with a little coarser finish than you would with the 40. That's one advantage on the 22–24.

Chairman Coffman: I would like to ask Vic: What is the finest stainless steel wire you are making now for cylinder wires?

Mr. Vigneron: One hundred in stainless steel type 315, I believe, and for bronze 120. I believe I'm correct in that. Does it go that fine, Lou, in stainless?

Lou Hubach (W. S. Tyler Co.): Oh, yes, in 316 and 304.

Chairman Coffman. Is there anyone who has run 100 mesh?

Mr. Fussell: I have run it, but it doesn't run long.

Mr. Vigneron: What backing did you use on that? That would be interesting to know.

Mr. Fussell: Eighteen or twenty. It certainly wasn't a 14. We figured that that coarser backer had to be fine. We finally found that a 70 ran quite well.

Mr. Vigneron: We have a recommended table, but that varies entirely upon the stock. Boards being made for a cement base, for example—will invariably have a very coarse backing.

Mr. Fussell: This was a high-grade printing on a uniflow vat, and we would have liked 100, but 100 wouldn't hold it. You couldn't hold it on but 70 did.

Chairman Coffman: Are there any other questions on any of these other papers?

John Fuko (River Raisen Paper): I would like to ask the gentleman from Buckman Laboratories what he would consider an average toxicant cost for good slime control treatment. Are you talking about 25 cents a lb., or 50, just in round numbers?

Mr. Dietzel (Buckman Laboratories, Inc.): That would vary considerably with the degree that slime can accumulate in a particular mill, but just running across the country I would say somewhere in the area of between 25 and 30 cents.

Mr. Fussell: Would that be with a chlorine?

Mr. Dietzel: There are a lot of other factors involved. The cost of chlorine is lower, but there are other factors ininvolved, such as corrosion and other things or that nature which should be part of the cost of the slime control program.

Question: I wonder if Mr. Connors would care to elaborate the ends of the rubber roll.

Mr. Connors: We have had experience where coverings come loose on the ends due to improper lubrication on the bearings, which would transfer the heat through the journal into the ends and affect the base of the rubber covering on the edges.

Question: Do you mean a water spray, or something on the end of the rolls?

Mr. Connors: I mean oil, or keeping the bearings lubricated so they don't get hot.

Question: You are referring to the lubrication of the bearings themselves?

Mr. Connors: Yes, sir.

Mr. Fuko: Mr. Root mentioned that Hydrapulpers can be used to help defibering action, and there could be a subsequent saving in refining horsepower later. I wonder if you could elaborate on that a little bit.

Edward M. Root (The Black-Clawson Co.): No. Perhaps I should say that for at least 20 years, to my knowledge, there have been various attempts made to follow the pulping operation with a defibering means ahead of the cleaning system. Now, many of us can go back far enough to remember the days 20 years ago when we had breaker beaters followed by settling troughs—period; and that was it.

And then, you know too that Arno Nickerson at one time put a defibering means between the breaker beater and the head end of the trough, where he wanted to scrub up the "uncomminuted," as he put it, bits of paper—ahead of the settling trough, so that dirt could be freed from them, and they could in turn be defibered and release the dirt to be settled in the settling trough. He used a conical plug refiner to do that, backing the plug off to scrub the fiber and not affect the nonpapermaking materials—matchsticks, glass, etc.

Well, various pieces of equipment have been devised to do a similar job. At present, we have another piece of equipment which at this point seems to be somewhat better suited to do a secondary defibering operation following the usual pulping, through either $^3/_8$ in., which is pretty common today, or $^1/_4$-in. perforations, which is somewhat less common.

So it is not a new concept, but it is an old concept which has been tried on various pieces of equipment with varying degree of success over a long period of time. I think we think today that we have a piece of equipment better suited, let us say, to do the job than we have had heretofore.

Mr. Fussell: Ned, along that line, you want to get something that will break up the fibers but won't break up plastics and similar materials.

Mr. Root: We want to preserve intact insofar as possible the nonpapermaking constituents, the glass, and rocks, which grind up into very small pieces, and the matchsticks, cellophane, and rubber bands, and preserve them as nearly as we can in their original form, and either centrifuge or screen them out, as the case may be. That needs to be done with a piece of equipment which is somewhat selective in its treatment, which will do the one without doing the other.

Mr. Fussell: Most of us would like, perhaps, to clean our underliner in the beater room, but I think most of us, with the present pulpers we have, would have to put secondary defibering in the system to do the job.

Mr. Root: That's very true, but recently pulping equipment was introduced on the market which will do a much more efficient job of initial defibering than heretofore. At least one that I know the most about was initially intended to be a slusher—that is all—a slusher. Our thought was to do the slushing, and then get the paper stock out in a secondary piece of equipment. We have made advances in this direction, and there are now means of improving the degree of defibering of the initial pulping, which would make it ideally suited to an installation where you want to have a minimum of equipment after the pulping stage.

Question: I'd like to direct a question to the Buckman man. In a board mill using mixed papers and using adequate slime control for bacteria, would you anticipate any trouble in your secondary treatment?

Mr. Dietzel: That would depend upon the chemistry of the compound used. If it were a compound that did not break down in its chemical structure, would not lose its activity, its biological activity, and continue on through the secondary recovery system, there might be some problem there. But, speaking of our products, that does not occur. In other words, activity is spent within the mill.

Question: Is that hard to control?

Mr. Dietzel: No, not necessarily.

Question: If you get too much in the treatment plant, you are in trouble?

Mr. Dietzel: No. We do not build up that type of residual that is effective in that high degree of contamination. Your microflora in the secondary treatment plant is exceedingly high. The toxicant is designed to control microorganisms at a much lower concentration of microorganisms. So, therefore, by the time it gets out through, it needs another shot of toxicant.

Chairman Coffman: The method which you recommend for treatment, the chemical you use—does it have a tendency to stay with the fiber, or does it stay in the water, or does it go out with the effluent?

Mr. Dietzel: The material that we would recommend would be one that would not be preferential to pulp. It would stay in the white water system. Essentially, there are no residuals in the paperboard, and that has been pretty well established.

Chairman Coffman: I think that's what you were primarily interested in, wasn't it? That you were afraid that you would get a buildup in hour white water?

Question: Yes, that it would foul up the secondary treatment.

Mr. Fuko: Mr. Kipp, is it true that you have a cleaning solution that can be sprayed on electric motors while they are operating, to clean out the paper dust or other extraneous material. And then take an air hose and blow it out?

Mr. Kipp (Oakite Products, Inc.): Yes, there are materials in our line that can be used for that and in the lines of other people in our industry.

The material is designed to remove a soil in a specified time, and evaporate before any of the moisture in that product will get into critical motor areas and cause any damage. The materials of our design, as well as those of competitors, are not only controlled in their evaporation rate but are also designed so that if any of the ingredients should get inside the motor, there is no cause for shorts, no motor burn-outs in case the soil or the solution should get inside; but they are designed to clean quickly and evaporate quickly, so that, following with an air blow-off, you knock off the residue and the soil.

J. C. Hintermayer (Huyck Felt Co.): I'd like to ask Mr. Kipp or any other member of the panel if they would just briefly explain the mechanisms that are at work chemical, physical, or others, that are eliminated by the use of cleaning compounds, or other chemicals.

Mr. Kipp: As I understand your question—let me paraphrase it this way. What causes felts to plug, and how do you unplug them? Is that right? It's a leading question, and there is no simple answer that I can give you.

All I can tell you is that we are in our industry extremely cautious about the recommendation of any chemical on any felt. Obviously, this suit is made of wool—or they told me it was. I'm very careful about the way I have it cleaned. I could throw it in the washing machine at home. We don't do it. I send it out and have experts do it.

So that when you men have a loaded felt—you know when it gets loaded, and why it gets loaded—you are interested in removing the loading residue, and doing it safety, because you want to use that felt again. Obviously, if this suit can be harmed with foam detergents, the felt in your mill can be harmed the same way, so when we approach a felt washing problem we have to go down the CSSA formula checklist we went down this morning. Not only is it a good quality felt to start with—but what are the components of that felt? How old is that felt? What kind of soil is in it? What about the temperature we can use on it? We have to answer

all these questions before we can make any recommendation. So the choice of cleaning solution has got to be made on that basis. Not only will it remove the soil, but will you have any felt left when the soil is removed?

Mr. Fussell: Some of us in dealing with Oakite and similar companies have run into your local people who are dealing with 50 or 100 industries, and have but a smattering of our problems.

Mr. Kipp: I think that it's a problem you run into in industry generally, is it not? In the home office and headquarters they specialize, and in the field they have to generalize. It has to be that way. So, the man that you call in may have an Oakite label on him, or a competitor's label, and he may bring a recommendation from the home office that he thinks is applicable, and it may not be worth a darn. Basically, what we try to do by having the experience in New York is to train the people properly here, so that they will not only be able to assimilate facts about paperboard, which is just one of many in the paper industry, but also about 50 other industries, as you mentioned.

Question: Mr. Connors, most board mills, I presume, establish a crown on their press rolls, based on the type and caliper of the board they are going to make. Obviously, they don't run a particular grade and caliper all the time. How does this affect the roll?

Mr. Connors: This is why a maintenance program is so important, because many times there are changing pressures used in press rolls to compensate for what you are talking about, which actually result in not having the proper crown. This is why grinding of the surface of the roll periodically will extend the life. When the crown is not proper, this results in uneven wear of the covering. Does this answer your question?

Question: Only in part. Have you made any statistical studies of what the life of a roll would be, depending on these variations?

Mr. Connors: That would cover quite a multitude, depending on the hardness of the covering and the other rolls involved in the other equipment used to remove water. If you are talking, let's say, of a pair of primary press rolls, regrinding maybe every six months or a year, depending on the speed and the diameters, the amount of rubber that is removed on each reconditioning would determine the overall life.

Question: Mr. Kipp, are there effective alkaline cleaners for removing wet-strength stock?

Mr. Kipp: From what area of the machine?

Question: From the pipes and the vat, the closed part of the machine.

Mr. Kipp: Yes, there are. There are two basic types available of an alkaline nature, a powder and a liquid, and the choice depends on the temperature that is available in the mill—that is, the facilities for heating the solution. The choice is also based on the amount of residue there, and how many units of equipment you are going to clean at the same time.

There are, to answer your question, alkaline type materials available.

Chairman Coffman: Are there any more questions?

Mr. Fussell: Perhaps Mr. Connors could review how they check press sections, and what they have found. If you might survey a press section, how would you do it?

Mr. Connors: You mean the survey of an entire machine?

Well, I think most of the people in the industry who have rubber roll covers offer that type of service. Their employees come to the mill when the felts are removed and the machine is down, to make a roll survey of the coverings. What is done during that type of a survey is to examine each covering along the line of the presses, taking nip widths at various loadings to determine whether the rolls are crowned, a general inspection of the covering, and a plastometer reading of the cover, all of which is accumulated in a service record book to bring the person up to date as to what the nip widths look like at the various loadings. This is a service, I think, which is extended by many roll suppliers. I'd just like to add that the important part is the making of changes in the relationship to nip widths. If I want to buy a roll that's bigger in diameter than the other one, which has a 50 plastometer, and I want to accomplish so much at the nip at a given load—am I going in the right direction or the wrong direction?—this is the type of research work that is becoming so important, I think, the relation of roll coverings and diameters.

Mr. Kipp: I'd like to address a question to Jack Connors. Which of the types of covering, including rubber, lasts the longest?

Mr. Connors: Well, obviously, a roll that is going the slowest and has the hardest covering, with the proper crown, should have the maximum life, because this will be chemically inert to most solutions. A roll that is softer, with a thicker cover, with heavier pressures, lasts less long.

Mr. Kipp: Would the longer-lasting rolls be neoprene? Would you get a longer last from a slow roll than if it were made of rubber?

Mr. Connors: The use of synthetics has greatly increased the overall life of a given roll in a given hardness, so when you ask: should this roll be neoprene or any other of the synthetics available?—you must speak in regard to the position of the roll on the machine, the plastometer which will do the job, and its thickness, before you can make a decision whether neoprene is the best for the job. Therefore, in the softer range synthetics many times are a longer life type of covering than in the harder range, where crude rubbers might well exceed them.

Chairman Coffman: I'd like, along those same lines, to ask Jack this: is not the life of the rubber covering on a roll somewhat in proportion to the amount of work that it does?

Mr. Connors: Well, that certainly is correct. The amount of work, I believe, of any product will determine its life. If you are talking in relationship to the extractor position versus some other press further down, then the pressures and the amount of water and the amount of work that's going to be required out of this roll will certainly have a bearing on its overall life. There's obviously no question there. And because it does more work doesn't necessarily mean that it would be harder. Many times a soft roll would be required to do more work, and consequently its life is somewhat limited.

John Cornell (Rockton Paperboard): What about hypoxic coverings for press rolls, Mr. Connors?

Mr. Connors: There are such coverings available, and they have been installed in various mills. Epoxys and phenolics are being used in breaker stack divisions, and in rare cases on the stack roll.

Mr. Cornell: Successfully?

Mr. Connors: Successful to some degree, depending on the grades of paper being manufactured. It seems that when a new top press roll is developed there is always a long period of time required to find out the grades that it will operate on, as well as the effect of the fillers in those grades. So many times it may be operating on the wrong grades, or is improperly installed.

We have made a couple of phenolic type rolls. Frankly, we have not yet found anything that was so outstanding that we have gone overboard with it.

Mr. Crawford: Mr. Chairman, I'd like to ask a question of Mr. Root. What do you do in a waste cleaning system when you want to clean bags that have had cement in them? There is very nice fiber—beautiful fiber—in the bags, but that cement on the inside is a rough customer to clean out. Would you care to answer?

Mr. Root: To be perfectly frank, we don't yet know how to get loose cement dust out of cement bags, except perhaps by dusting the bag before you put it into the pulping equip-

ment. You can spend quite a lot of money, if you wish to, for dusting equipment, but dusting equipment when you are handling the bag in its original form is not, at best, very effective.

There is—or there are, I should say, because I know of one or two—dry cleaning methods that are being pushed on the market now for cleaning a raw furnish before it goes into the process. I'm interested in it personally, and we, as a part of the industry, are interested in it because it is a long felt need. Once we get it to the pulper, as far as we are concerned in our present state of development. we don't know how to cope with it, to be perfectly frank.

MR. FUSSELL: I'd like to comment on that. E. D. Jones are doing some research along that line, and they may be of some help in the future.

CHAIRMAN COFFMAN: Have you done any work on cement bags through a de-asphalting system?

MR. ROOT: Yes. Your question relates more particularly to de-asphalting as such than cement bags and their relation to it?

CHAIRMAN COFFMAN: No. I know what will happen to the asphalt, but what happens to the cement?

MR. ROOT: I don't know. I don't think that the de-asphalting systems on the market today, as such, will do anything to the cement in changing its form. Now, whether they will make it agglomerate if that's the proper word and stick up the system or not—I really don't know whether it will or not. I don't think so, but I don't know.

MR. CRAWFORD: I'd like to comment that, from experience, they will not conglomerate, which you suspected, and if you don't get them out before you throw them into your mixed papers, you will find them in all the little pockets and the corners of your system, because they are colloidal. They will be carried along, and they will settle along the periphery, the edges of your paper. They build up gradually and very firmly, to a point where you will have to get in there and chip them out.

MR. ROOT: Does that mean, then, they won't get into the paper?

MR. CRAWFORD: To a very small extent they will. You will never notice a colloid in the paper, but they are colloidal in nature and string out along the edge of your pipes, and so forth, and then they begin to build up. Some of it will be in the paper, sure, but we can sell that.

CHAIRMAN COFFMAN: Are there any other questions now? Well, I know this panel is willing and able to answer, but if you have exhausted your questions, we will adjourn the meeting.

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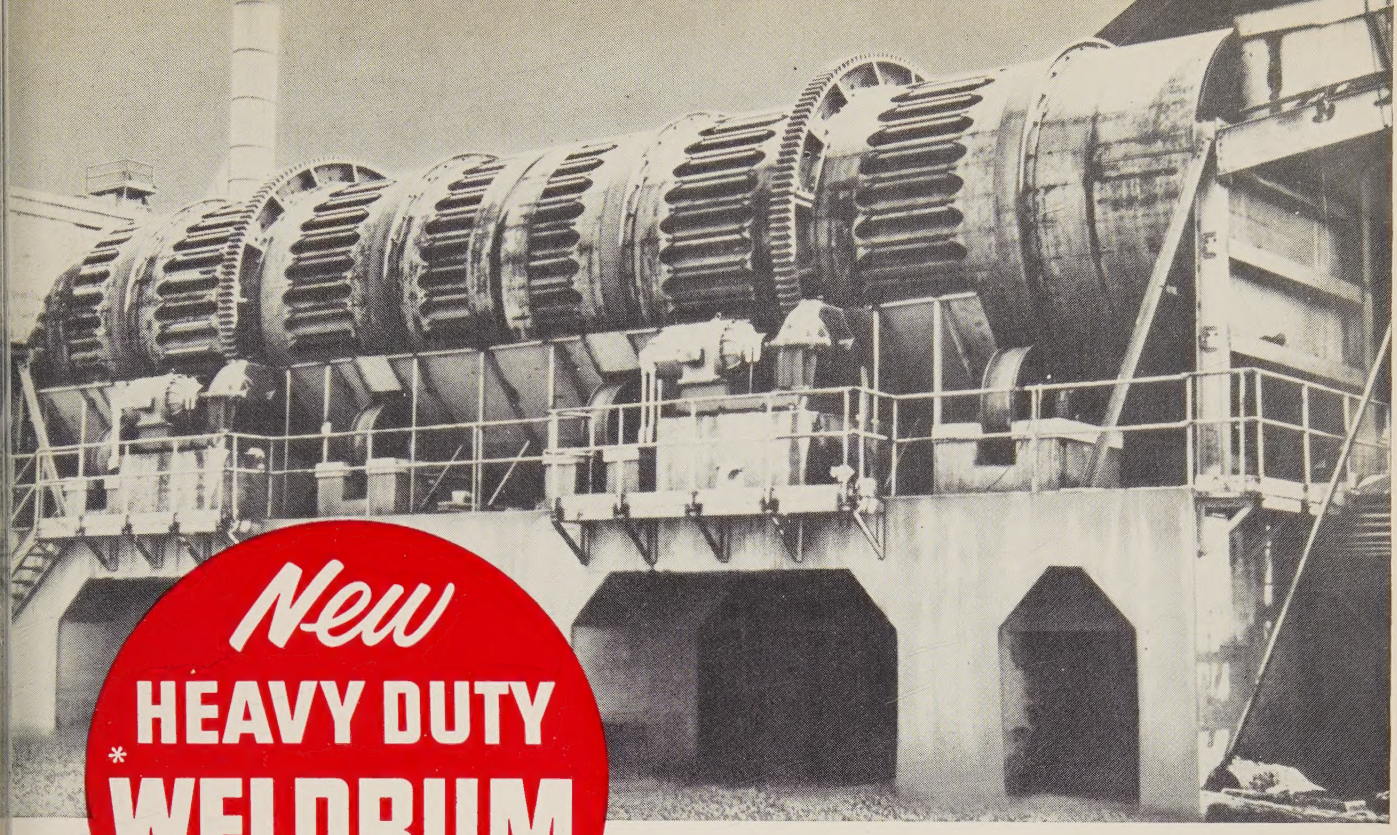

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